Health Canada Santé Canada

2001 Report on Occupational Radiation Exposures in Canada

Canada

2001 Report on Occupational Radiation Exposures in Canada

Safe Environments Programme
Healthy Environments and Consumer Safety Branch

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Abstract

The report provides statistics on occupational radiation exposures for use by regulatory authorities, organizations and private individuals. Out of a total of 129,935 monitored workers, 4 annual doses exceeded the regulatory limit of 50 mSv in 2000. Out of 58 specified job categories, 28 had a smaller annual average in 2000 than in 1999, 21 had a higher average, and 9 had the same average rounded to 0.01 mSv. The figures reflect a sustained effort in keeping the occupational doses low.

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Introduction

This series of reports provides statistics on occupational radiation exposures of monitored workers in Canada. The statistics are intended to assist regulatory authorities, organizations, and private individuals in comparing incurred occupational radiation exposures with national or provincial/ territorial averages and trends in similar occupations. Previous issues of the report can be obtained from the authors[1-5].

The information is based on the data in the National Dose Registry (NDR) maintained by the Radiation Protection Bureau of Health Canada[6]. The Registry is a centralized record-keeping system containing dose information on all monitored workers in Canada. It includes data submitted by nuclear power generating stations, Atomic Energy of Canada Ltd., uranium mines, and dosimeter processing companies.

Information for input into the NDR is received either via a direct link or by mail in computer readable form.

The report provides data on the two consecutive years prior to the year in which the data are extracted from the database. The data for the second (i.e. more recent) year will be close to stable at the time of data extraction. Some changes may still occur, for which the most frequent causes are: (1) a high dose to a dosimeter is judged to be non-personal after investigation; (2) a job category of a worker is updated; or, (3) dosimeters or data are returned late. The report therefore contains preliminary data on the second year (Table 1), and more complete data on the first year (Tables 2-4).

For a description and a guide to interpretation of the data, the reader is referred to the next section "General Comments". The section "Comments specific to this report" has been included to address situations that do not recur from year to year.

General Comments

The statistics include doses as they exist in the database at the time they are extracted for analysis, which in the case of this report is August 18, 2001. Doses are assigned to the year in which the dosimeter was issued, even though some of the dosimeters may actually have been worn during part of the subsequent year. As the statistics are determined in the same manner each year, the annual dose figures are based on a 12-month period, though not necessarily the strict calendar year.

Dose records submitted by outside organizations such as nuclear power generating stations, uranium mines, and commercial processors, are included to the extent that they have been received. The doses are representative of the calendar year only if the fourth quarter records have been received by the time of analysis. When statistics are based on partial data, the fact is indicated in the section "Comments specific to this report".

All doses are in International System (SI) units and presented to the nearest hundredth of a millisievert (1 mSv = 100 mrem). For the external whole body doses various organizations have set recording thresholds from 0 to 0.2 mSv.

The words "dose" and "exposure" are used interchangeably in this report. Doses of different types of radiation are expressed in mSv and added to give the effective dose stated in the report. The following dose types may be included:

- External whole body gamma.
- External whole body high energy beta.
- External whole body X-ray.
- External whole body neutron.
- Internal whole body tritium, as determined by urinalysis.
- Radon progeny exposures, converted from WLM values (see below).

All types of exposure are given in one total. In Tables 3 and 4, the percentage contribution of radon progeny and tritium components are indicated for occupations related to mining and nuclear power generation, respectively. Skin doses and extremity doses are not included in the report but are recorded in the database.

In the NDR database, radon progeny exposures are expressed in Working Level Months (WLM), which are in most cases calculated by the mines on the basis of area monitoring[7]. In the report the radon progeny exposures are converted to equivalent doses (in mSv). The value used in this report is 5 mSv/WLM, in accordance with the new CNSC regulations[8], which came into force on May 31, 2000.

Job category designations are based on a standard list provided by the Registry and are updated when the Registry is notified. The job category is selected by the organization from a standard list maintained by the NDR. The NDR keeps the most recent job category that an organization submits for a worker in a given year. However, a worker who has been monitored by more than one organization, can have records under more than one job category for the same year. Some organizations have their own job classifications schemes, and translate them into the Registry's standardized list prior to submission of the records.

In this report, the data are tabulated as follows:

2000: Preliminary analysis

Table 1:

Table 1 gives the annual dose distributions by job category.

1999: Final Analysis

Table 2:

Table 2 contains dose statistics by job category and province or territory.

Table 3:

Table 3 contains dose statistics by age and sex. In this table job categories have been grouped into "job sectors".

Table 4:

Table 4 contains various dose statistics by job category. The table also shows the parameters of the lognormal or hybrid lognormal distribution for positive doses, as produced by maximum likelihood estimation. From that information, it is possible to calculate estimates and confidence intervals of statistics of the distribution. For a more detailed discussion the reader is referred to the Appendix.

Table 4 also includes an accumulated dose distribution over the 5 year period 1995-1999 for the workers under the given job category.

Finally, Table 4 contains a histogram that shows the trend in average annual doses over the period 1990-1999.

It should be noted that in the tables, a worker is counted more than once if he (she) works in more than one job category, in more than one province, or in more than on job sector in the same year. For this reason the totals in Tables 2-4 may slightly differ.

Comments specific to this report

Job category information is not provided by all dosimetry companies. In the two previous reports, such unreported job categories in the 1996-1998 data were inferred from earlier information on the same worker. Starting with the 1999 data, these job categories will no longer be inferred, in view of the ever increasing likelihood of job changes. This is expected to be a temporary problem which will disappear when the NDR receives complete job class information.

At the time of extracting the data, we had not received full sets of exposure data for 2000 for all mine sites. This affects some of the statistics in Table 1. This problem will have been corrected in final analysis for 2000 in the next report.

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8. Regulations of the Nuclear Safety and Control Act, Canada Gazette, June 21, 2000, part 2. For more information see the web site of the CNSC (formerly AECB): http://www.nuclearsafety.gc.ca/eng/index.htm

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2000 Preliminary Analysis

Table 1
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Administration:										
Administrator	345	165	4	0	0	0	0	514	0.14	0.42
Office staff	3191	277	10	5	2	0	0	3485	0.05	0.55
Safety officer	105	20	2	0	0	0	0	127	0.07	0.40
Industry and Research:										
Industrial radiographer	1380	369	189	304	369	42	1	2654	2.42	5.05
Instructor (non-medical)	169	6	0	0	0	0	0	175	0.01	0.32
Instrument technician	1707	250	27	18	10	0	0	2012	0.14	0.92
Laboratory technician (industrial)	2768	385	45	25	7	0	0	3230	0.11	0.76
Nuclear fuel processor	26	42	14	19	13	0	0	114	1.68	2.18
Scientist/engineer (field)	661	471	33	13	9	0	0	1187	0.29	0.65
Scientist/engineer (laboratory)	4393	151	10	2	1	0	0	4557	0.02	0.46
Tradesman	39	0	0	0	0	0	0	39	0.00	0.00
Well logger	395	125	44	41	21	0	0	626	0.70	1.90
Medicine:										
Chiropractor	956	31	1	1	0	0	0	989	0.02	0.49
Dental assistant	10339	71	3	0	1	0	0	10414	0.00	0.56
Dental hygienist	7496	62	5	0	4	0	0	7567	0.01	0.98
Dental therapist/nurse	98	3	0	0	0	0	0	101	0.01	0.23
Dentist	6927	82	4	3	1	0	0	7017	0.01	0.68
Gynaecologist	17	0	0	0	0	0	0	17	0.00	0.00
Laboratory technician (medical)	2590	99	17	13	1	0	1	2721	0.07	1.41
Medical physicist	253	16	2	1	1	1	0	274	0.22	2.86
Medical radiation technologist	9981	647	51	48	12	0	1	10740	0.06	0.83
Nuclear medicine technologist	423	252	223	312	51	0	0	1261	1.41	2.12
Nurse	3603	203	16	11	0	0	0	3833	0.03	0.55
Physician	1420	150	25	17	3	0	0	1615	0.10	0.87
Radiation therapist	1038	94	11	9	1	0	0	1153	0.07	0.73
Radiologist (diagnostic)	1417	114	16	8	7	0	0	1562	0.09	1.02
Radiologist (therapeutic)	160	12	1	1	0	0	0	174	0.04	0.54
Veterinarian	3719	168	6	2	0	0	0	3895	0.02	0.40
Veterinary technician	1424	48	10	3	0	0	0	1485	0.03	0.68
Ward aid/orderly	1304	62	7	6	1	0	1	1381	0.08	1.47

Table 1 (Cont'd)
Breakdown of annual doses by job category for all of Canada

Job Category	Distribution of workers over dose intervals							Number of Workers	Avg. Dose (mSv)	Avg. of Positive Doses
	0 mSv	>0-1 mSv	>1-2 mSv	>2-5 mSv	>5-20 mSv	>20-50 mSv	>50 mSv			
Nuclear Power:										
Reactor - administration	3628	531	95	85	34	0	0	4373	0.18	1.08
Reactor - chemical and radiation control	103	138	34	42	30	0	0	347	1.53	2.17
Reactor - construction	922	345	122	203	220	0	0	1812	1.56	3.17
Reactor - control technician	91	48	14	9	7	0	0	169	0.82	1.78
Reactor - electrical maintenance	486	294	124	121	38	0	0	1063	0.85	1.56
Reactor - fuel handling	4	6	2	11	29	0	0	52	5.64	6.11
Reactor - general maintenance	849	244	80	106	74	0	0	1353	0.86	2.31
Reactor - health physics	51	13	4	7	1	0	0	76	0.45	1.36
Reactor - industrial radiographer	9	10	7	20	8	0	0	54	2.57	3.08
Reactor - mechanical maintenance	411	349	130	176	219	0	0	1285	2.10	3.08
Reactor - operations	710	775	207	168	124	0	0	1984	1.12	1.74
Reactor - scientific/professional	1468	300	81	72	63	0	0	1984	0.48	1.84
Reactor - training	68	15	5	2	3	0	0	93	0.43	1.58
Reactor - visitor	3170	145	45	40	41	0	0	3441	0.17	2.13
Uranium Mining:										
Uranium mine electrician	7	2	1	0	0	0	0	10	0.22	0.72
Uranium mine mill maintenance	3	44	34	36	1	0	0	118	1.56	1.60
Uranium mine mill worker	2	51	37	47	12	0	0	149	2.12	2.15
Uranium mine nurse	9	5	0	0	0	0	0	14	0.08	0.21
Uranium mine office staff	81	44	1	0	0	0	0	126	0.11	0.31
Uranium mine support worker	40	150	52	49	13	0	0	304	1.27	1.47
Uranium mine surface maintenance	40	51	14	3	0	0	0	108	0.51	0.82
Uranium mine surface miner	5	10	4	6	0	0	0	25	1.17	1.48
Uranium mine surface personnel	42	72	12	3	0	0	0	129	0.36	0.54
Uranium mine surface support worker	54	87	5	5	0	0	0	151	0.30	0.47
Uranium mine underground maintenance	14	133	40	5	1	0	0	193	0.70	0.75
Uranium mine underground miner	26	90	36	75	53	0	0	280	2.82	3.10
Uranium mine underground personnel	21	46	23	10	3	0	0	103	1.01	1.27
Uranium mine visitor	48	75	0	0	0	0	0	123	0.12	0.19
Miscellaneous/Unknown										
Miscellaneous/unknown	28824	9037	1090	675	250	11	0	39887	0.23	0.83

Table 2
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Administration													
Administrator	5	0	8	2	50	371	11	3	36	27	0	0	513
	.14	.00	.00	.00	.00	.17	.00	.00	.01	.00	.00	.00	.13
Office staff	36	6	81	66	651	1878	241	67	182	261	10	0	3479
	.01	.00	.00	.02	.02	.07	.01	.01	.03	.00	.00	.00	.04
Safety officer	3	1	8	2	22	43	12	2	4	10	0	0	107
	.00	.50	.05	.10	.05	.10	.00	.00	.00	.03	.00	.00	.06
OVERALL	**44**	**7**	**97**	**70**	**723**	**2292**	**264**	**72**	**222**	**298**	**10**	**0**	**4099**
	.02	**.07**	**.01**	**.02**	**.02**	**.68**	**.01**	**.01**	**.02**	**.00**	**.00**	**.00**	**.05**
Industry and Research													
Industrial radiographer	33	0	85	104	391	635	36	155	699	197	0	4	2539
	.93	.00	2.76	2.00	1.34	1.77	.24	1.73	4.30	1.41	.00	.10	2.58
Instructor (non-medical)	9	3	23	3	28	44	6	22	13	19	1	0	171
	.00	.00	.10	.00	.00	.00	.00	.00	.12	.00	.00	.00	.02
Instrument technician	90	1	61	65	463	874	49	20	152	119	2	0	1896
	.01	.00	.06	.30	.07	.17	.01	.07	.19	.02	.00	.00	.12
Laboratory technician (industrial)	58	9	81	50	851	1365	262	189	222	167	0	0	3254
	.12	.09	.02	.05	.06	.18	.01	.02	.05	.08	.00	.00	.10
Nuclear fuel processor	0	0	0	0	0	118	1	0	1	0	0	0	120
	.00	.00	.00	.00	.00	1.51	.00	.00	.00	.00	.00	.00	1.49
Scientist/engineer (field)	7	0	29	49	62	801	18	41	87	93	9	0	1196
	.00	.00	.55	.68	.31	.30	.00	.02	1.04	.07	.11	.00	.34
Scientist/engineer (laboratory)	116	3	127	25	1956	1107	149	89	119	633	0	0	4324
	.01	.00	.01	.08	.02	.02	.02	.00	.03	.03	.00	.00	.02
Tradesman	0	0	0	0	5	18	0	0	2	5	0	0	30
	.00	.00	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00	.01
Well logger	0	0	1	0	1	0	0	39	510	12	1	0	564
	.00	.00	.00	.00	.00	.00	.00	.04	.56	.03	.00	.00	.51
OVERALL	**313**	**16**	**407**	**296**	**3757**	**4962**	**521**	**555**	**2005**	**1245**	**13**	**4**	**14094**
	.13	**.01**	**.64**	**.90**	**.18**	**.39**	**.03**	**.50**	**2.14**	**.28**	**.08**	**.10**	**.57**
Medicine													
Chiropractor	3	0	3	3	442	298	63	10	121	24	0	0	967
	.00	.00	.00	.00	.03	.00	.03	.00	.01	.17	.00	.00	.02
Dental assistant	112	61	292	134	2118	4784	655	300	689	602	20	5	9772
	.01	.00	.01	.02	.00	.00	.00	.02	.02	.00	.00	.00	.01
Dental hygienist	49	19	168	101	2534	3184	438	127	291	342	10	4	7267
	.02	.00	.01	.00	.00	.01	.00	.04	.00	.00	.02	.00	.01
Dental therapist/nurse	1	0	0	0	7	19	11	32	2	7	5	9	93
	.00	.00	.00	.00	.00	.00	.02	.01	.00	.00	.00	.12	.02
Dentist	99	12	153	84	2591	2837	508	123	279	267	27	4	6984
	.03	.00	.00	.01	.01	.01	.01	.00	.01	.01	.00	.00	.01
Gynaecologist	1	0	1	0	3	6	5	0	1	1	1	0	19
	.00	.00	.00	.00	.00	.03	.00	.00	.00	.00	.00	.00	.01
Laboratory technician (medical)	39	1	150	3	1095	730	121	63	139	323	1	0	2665
	.01	.00	.02	.00	.04	.21	.03	.06	.04	.01	.00	.00	.08
Medical physicist	3	1	11	4	105	65	12	10	1	56	1	0	269
	.00	.00	.05	.00	.02	.05	.09	.03	.00	.01	.00	.00	.03
Medical radiation technologist	307	73	244	278	2785	3724	445	677	935	1088	24	10	10590
	.15	.06	.06	.06	.05	.05	.03	.03	.04	.05	.00	.00	.05

Table 2 (Cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Medicine (cont'd)													
Nuclear Medicine Technologist	20	5	48	29	472	418	80	29	37	92	0	0	1230
	1.79	.76	1.65	1.17	1.74	1.12	.90	1.62	1.33	.51	.00	.00	1.35
Nurse	165	4	155	107	1051	1406	269	73	70	236	118	83	3737
	.08	.40	.06	.09	.03	.05	.01	.15	.03	.03	.00	.03	.04
Physician	41	5	57	23	648	574	62	44	48	138	5	3	1648
	.02	.00	.12	.03	.16	.11	.15	.15	.00	.04	.00	.00	.12
Radiation therapist	11	3	45	16	280	353	51	58	12	201	0	0	1030
	.44	.13	.28	.55	.22	.04	.11	.06	.03	.04	.00	.00	.12
Radiologist (diagnostic)	51	7	39	34	514	531	56	46	78	162	5	0	1533
	.10	.06	.42	.07	.14	.12	.09	.08	.17	.08	.00	.00	.13
Radiologist (therapeutic)	3	1	3	7	59	56	13	4	0	25	0	0	171
	.10	.00	.00	.00	.03	.04	.02	.20	.00	.02	.00	.00	.04
Veterinarian	36	39	172	73	721	1242	219	162	689	676	0	11	4040
	.01	.08	.00	.04	.01	.04	.01	.01	.01	.03	.00	.03	.02
Veterinary technician	4	4	31	10	163	276	36	21	124	141	0	7	817
	.00	.00	.05	.00	.01	.03	.01	.00	.00	.02	.00	.00	.02
Ward aid/orderly	19	14	18	38	828	239	112	25	46	127	5	0	1471
	.05	.03	.05	.02	.04	.03	.03	.05	.00	.01	.00	.00	.03
OVERALL	**964**	**249**	**1590**	**944**	**16416**	**20742**	**3166**	**1804**	**3562**	**4508**	**222**	**136**	**54303**
	.12	**.06**	**.09**	**.08**	**.08**	**.06**	**.04**	**.06**	**.04**	**.04**	**.00**	**.03**	**.06**
Nuclear Power													
	0	0	0	197	326	3977	0	0	0	0	0	0	4500
Reactor - administration	.00	.00	.00	.37	.29	.23	.00	.00	.00	.00	.00	.00	.24
Reactor - chemical and radiation control	0	0	0	26	22	310	0	0	0	0	0	0	358
	.00	.00	.00	.65	1.82	1.64	.00	.00	.00	.00	.00	.00	1.58
Reactor - construction	0	0	0	0	96	1502	0	0	0	0	0	0	1598
	.00	.00	.00	.00	.33	1.92	.00	.00	.00	.00	.00	.00	1.82
Reactor - control technician	0	0	0	0	133	0	0	0	0	0	0	0	133
	.00	.00	.00	.00	1.22	.00	.00	.00	.00	.00	.00	.00	1.22
Reactor - electrical maintenance	0	0	0	87	47	852	0	0	0	0	0	0	986
	.00	.00	.00	.86	1.39	1.04	.00	.00	.00	.00	.00	.00	1.04
Reactor - fuel handling	0	0	0	30	15	0	0	0	0	0	0	0	45
	.00	.00	.00	7.54	3.87	.00	.00	.00	.00	.00	.00	.00	6.31
Reactor - general maintenance	0	0	0	257	89	954	0	0	0	0	0	0	1300
	.00	.00	.00	.70	2.76	.96	.00	.00	.00	.00	.00	.00	1.03
Reactor - health physics	0	0	0	34	23	19	0	0	0	0	0	0	76
	.00	.00	.00	.84	.40	.02	.00	.00	.00	.00	.00	.00	.50
Reactor - industrial radiographer	0	0	0	0	9	8	0	0	0	0	0	0	17
	.00	.00	.00	.00	3.99	.66	.00	.00	.00	.00	.00	.00	2.42
Reactor - mechanical maintenance	0	0	0	198	181	911	0	0	0	0	0	0	1290
	.00	.00	.00	2.22	3.88	2.33	.00	.00	.00	.00	.00	.00	2.53
Reactor - operations	0	0	0	103	95	1730	0	0	0	0	0	0	1928
	.00	.00	.00	.38	1.34	1.18	.00	.00	.00	.00	.00	.00	1.15
Reactor - scientific/professional	0	0	0	332	173	1048	0	0	0	0	0	0	1553
	.00	.00	.00	.38	.82	.55	.00	.00	.00	.00	.00	.00	.54
Reactor - training	0	0	0	32	59	2	0	0	0	0	0	0	93
	.00	.00	.00	1.31	.60	.00	.00	.00	.00	.00	.00	.00	.83
Reactor - visitor	0	0	0	0	1107	1584	0	0	0	0	0	0	2691
	.00	.00	.00	.00	.04	.65	.00	.00	.00	.00	.00	.00	.40
OVERALL	**0**	**0**	**0**	**1296**	**2375**	**12897**	**0**	**0**	**0**	**0**	**0**	**0**	**16568**
	.00	**.00**	**.00**	**.96**	**.75**	**.92**	**.00**	**.00**	**.00**	**.00**	**.00**	**.00**	**.90**

Table 2 (Cont'd)
Number of workers (top) and average whole body dose in mSv (bottom) by job category and province/territory

Job Sector and Category	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Yukon	Canada
Uranium Mining													
Uranium mine electrician	0	0	0	0	0	0	0	17	0	0	0	0	17
	.00	.00	.00	.00	.00	.00	.00	.29	.00	.00	.00	.00	.29
Uranium mine mill maintenance	0	0	0	0	0	0	0	147	0	0	0	0	147
	.00	.00	.00	.00	.00	.00	.00	1.47	.00	.00	.00	.00	1.47
Uranium mine mill worker	0	0	0	0	0	4	0	185	0	0	0	0	189
	.00	.00	.00	.00	.00	.05	.00	1.82	.00	.00	.00	.00	1.79
Uranium mine nurse	0	0	0	0	0	0	0	22	0	0	0	0	22
	.00	.00	.00	.00	.00	.00	.00	.05	.00	.00	.00	.00	.05
Uranium mine office staff	0	0	0	0	0	0	0	166	0	0	0	0	166
	.00	.00	.00	.00	.00	.00	.00	.18	.00	.00	.00	.00	.18
Uranium mine support worker	0	0	0	0	0	2	0	464	0	0	0	0	466
	.00	.00	.00	.00	.00	.00	.00	1.17	.00	.00	.00	.00	1.16
Uranium mine surface maintenance	0	0	0	0	0	2	0	217	0	0	0	0	219
	.00	.00	.00	.00	.00	.00	.00	.41	.00	.00	.00	.00	.40
Uranium mine surface miner	0	0	0	0	0	0	0	74	0	0	0	0	74
	.00	.00	.00	.00	.00	.00	.00	.83	.00	.00	.00	.00	.83
Uranium mine surface personnel	0	0	0	0	0	19	0	158	0	0	0	0	177
	.00	.00	.00	.00	.00	.07	.00	.39	.00	.00	.00	.00	.35
Uranium mine surface support worker	0	0	0	0	0	12	0	217	0	0	0	0	229
	.00	.00	.00	.00	.00	.03	.00	.31	.00	.00	.00	.00	.30
Uranium mine underground maintenance	0	0	0	0	0	0	0	204	0	0	0	0	204
	.00	.00	.00	.00	.00	.00	.00	.90	.00	.00	.00	.00	.90
Uranium mine underground miner	0	0	0	0	0	2	0	339	0	0	0	0	341
	.00	.00	.00	.00	.00	.00	.00	2.61	.00	.00	.00	.00	2.60
Uranium mine underground personnel	0	0	0	0	0	21	0	138	0	0	0	0	159
	.00	.00	.00	.00	.00	.01	.00	1.14	.00	.00	.00	.00	.99
Uranium mine visitor	0	0	0	0	0	0	0	239	0	0	0	0	239
	.00	.00	.00	.00	.00	.00	.00	.11	.00	.00	.00	.00	.11
OVERALL	**0**	**0**	**0**	**0**	**0**	**62**	**0**	**2587**	**0**	**0**	**0**	**0**	**2649**
	.00	**.00**	**.00**	**.00**	**.00**	**.03**	**.00**	**1.03**	**.00**	**.00**	**.00**	**.00**	**1.01**

Table 3
Dose distribution broken down by job sector, age and sex.

			Sex			
Job Sector	Age	Statistic	Male	Female	Unknown	Overall
Administration	Below 25	Number of Workers	10	255	1	266
		Average dose (mSv)	.11	.01	.00	.01
	25-34	Number of Workers	43	909	1	953
		Average dose (mSv)	.17	.02	.00	.03
	35-44	Number of Workers	157	1213	2	1372
		Average dose (mSv)	.22	.04	.00	.06
	45-54	Number of Workers	179	964	0	1143
		Average dose (mSv)	.24	.05	.00	.08
	55-up	Number of Workers	70	281	2	353
		Average dose (mSv)	.22	.03	.00	.07
	Unknown	Number of Workers	0	7	0	7
		Average dose (mSv)	.00	.00	.00	.00
	Overall	**Number of Workers**	**459**	**3629**	**6**	**4094**
		Average dose (mSv)	**.22**	**.03**	**.00**	**.05**
Industry and Research	Below 25	Number of Workers	880	531	2	1413
		Average dose (mSv)	1.46	.11	.00	.95
	25-34	Number of Workers	2706	1232	1	3939
		Average dose (mSv)	.95	.05	.00	.67
	35-44	Number of Workers	3549	1054	7	4610
		Average dose (mSv)	.75	.09	.23	.60
	45-54	Number of Workers	2488	459	3	2950
		Average dose (mSv)	.40	.09	.00	.35
	55-up	Number of Workers	918	94	0	1012
		Average dose (mSv)	.33	.21	.00	.32
	Unknown	Number of Workers	16	7	5	28
		Average dose (mSv)	.03	.00	.32	.07
	Overall	**Number of Workers**	**10557**	**3377**	**18**	**13952**
		Average dose (mSv)	**.74**	**.08**	**.18**	**.58**
Medicine	Below 25	Number of Workers	348	4325	3	4676
		Average dose (mSv)	.11	.03	.00	.04
	25-34	Number of Workers	2806	13843	8	16657
		Average dose (mSv)	.11	.06	.00	.07
	35-44	Number of Workers	4558	12208	5	16771
		Average dose (mSv)	.09	.06	.00	.07
	45-54	Number of Workers	4196	7174	3	11373
		Average dose (mSv)	.05	.07	.00	.06
	55-up	Number of Workers	2543	1584	5	4132
		Average dose (mSv)	.06	.03	.00	.05
	Unknown	Number of Workers	23	47	11	81
		Average dose (mSv)	.00	.02	.00	.01
	Overall	**Number of Workers**	**14474**	**39181**	**35**	**53690**
		Average dose (mSv)	**.08**	**.06**	**.00**	**.06**

Table 3 (Cont'd)
Dose distribution broken down by job sector, age and sex.

			Sex			
Job Sector	Age	Statistic	Male	Female	Unknown	Overall
Nuclear Power	Below 25	Number of Workers	399	145	0	544
		Average dose (mSv)	.56	.15	.00	.45
		% tritium	11.1	16.3	.0	11.5
	25-34	Number of Workers	1864	429	0	2293
		Average dose (mSv)	1.31	.28	.00	1.11
		% tritium	18.8	24.1	.0	19.0
	35-44	Number of Workers	5154	776	0	5930
		Average dose (mSv)	1.22	.24	.00	1.09
		% tritium	17.8	23.3	.0	17.9
	45-54	Number of Workers	5126	462	0	5588
		Average dose (mSv)	.90	.13	.00	.84
		% tritium	14.5	30.0	.0	14.7
	55-up	Number of Workers	1761	65	0	1826
		Average dose (mSv)	.52	.10	.00	.51
		% tritium	16.3	19.8	.0	16.3
	Unknown	Number of Workers	2	2	0	4
		Average dose (mSv)	.33	.39	.00	.36
		% tritium	.0	.0	.0	.0
	Overall	**Number of Workers**	**14306**	**1879**	**0**	**16185**
		Average dose (mSv)	**1.01**	**.21**	**.00**	**.92**
		% tritium	**16.7**	**24.0**	**.0**	**16.9**
Mining	Below 25	Number of Workers	165	26	0	191
		Average dose (mSv)	.76	.59	.00	.74
		% radon progeny	73.8	51.1	.0	71.3
	25-34	Number of Workers	628	51	1	680
		Average dose (mSv)	1.28	.30	.20	1.20
		% radon progeny	64.2	56.4	100.0	64.1
	35-44	Number of Workers	795	56	1	852
		Average dose (mSv)	1.20	.65	.45	1.16
		% radon progeny	65.1	58.0	100.0	64.9
	45-54	Number of Workers	525	24	1	550
		Average dose (mSv)	1.02	.36	.75	.99
		% radon progeny	60.2	39.5	100.0	59.9
	55-up	Number of Workers	189	5	0	194
		Average dose (mSv)	.91	.16	.00	.90
		% radon progeny	62.0	75.0	.0	62.1
	Unknown	Number of Workers	4	0	0	4
		Average dose (mSv)	.01	.00	.00	.01
		% radon progeny	100.0	.0	.0	100.0
	Overall	**Number of Workers**	**2306**	**162**	**3**	**2471**
		Average dose (mSv)	**1.12**	**.47**	**.47**	**1.08**
		% radon progeny	**64.0**	**54.4**	**100.0**	**63.8**

1999 Final Analysis

Table 4
Dose Statistics by job category
Administrator

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	335	0.00	0.00
>0-1	175	62.45	0.36
>1-2	3	3.24	1.08
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	513	65.69	0.13
			Five year period 1995-1999
0	510	0.00	0.00
>0-5	387	335.93	0.87
>5-25	1	8.60	8.60
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	898	344.53	0.38

Hybrid lognormal parameters for positive doses in 1999:
ρ: 6.1533
μ: +2.9044
σ^2: 3.5465
Sample size: 178
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

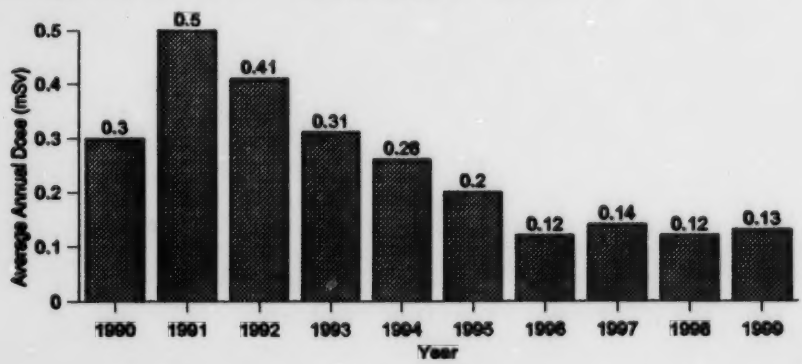


Table 4 (Cont'd)
Office Staff

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	3148	0.00	0.00
>0-1	318	123.86	0.39
>1-2	9	14.08	1.56
>2-5	4	11.04	2.76
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	3479	148.98	0.04
			Five year period 1995-1999
0	5055	0.00	0.00
>0-5	1276	1083.38	0.85
>5-25	13	105.74	8.13
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	6344	1189.12	0.19

Lognormal parameters for positive doses in 1999:
μ: -1.0356
σ^2: 0.4782
Sample size: 331
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

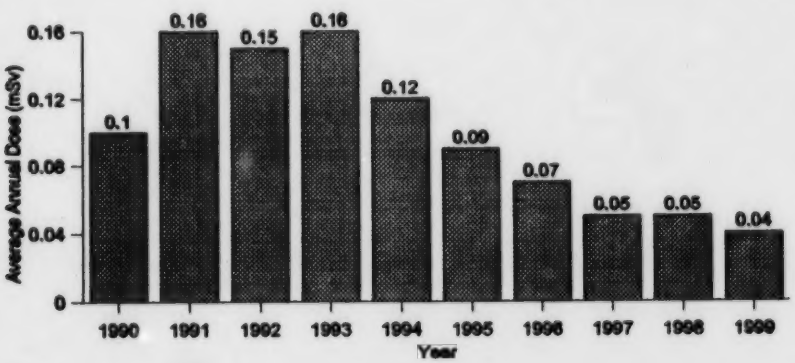


Table 4 (Cont'd)
Safety Officer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	88	0.00	0.00
>0-1	18	6.70	0.37
>1-2	0	0.00	0.00
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	106	6.70	0.06
			Five year period 1995-1999
0	108	0.00	0.00
>0-5	65	61.36	0.94
>5-25	1	11.00	11.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	174	72.36	0.42

Hybrid lognormal parameters for positive doses in 1999:
ρ: 10.6945
μ: + 5.2041
σ^2: 6.2515
Sample size: 18
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

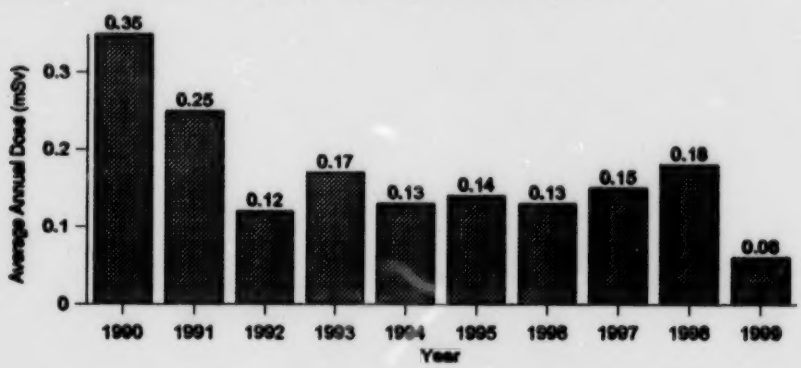


Table 4 (Cont'd)
Industrial Radiographer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	1308	0.00	0.00
>0-1	328	165.33	0.50
>1-2	165	252.19	1.53
>2-5	278	938.48	3.38
>5-20	320	3188.54	9.96
>20-50	45	1249.37	27.76
>50	2	748.25	374.13
Total	2446	6542.16	2.67
			Five year period 1995-1999
0	1455	0.00	0.00
>0-5	1073	1587.08	1.48
>5-25	755	9740.18	12.90
>25-100	459	20532.36	44.73
>100	29	4288.85	147.89
Total	3771	36148.47	9.59

Hybrid lognormal parameters for positive doses in 1999 (highest dose of 673.20 mSv removed):
ρ: 0.0343
μ: -2.3254
σ^2: 2.3434
Sample size: 1137
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

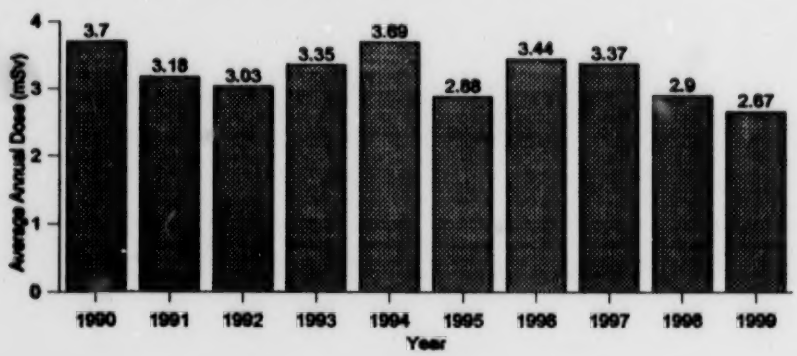


Table 4 (Cont'd)
Instructor (Non Medical)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	164	0.00	0.00
>0-1	5	1.60	0.32
>1-2	2	2.50	1.25
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	171	4.10	0.02
			Five year period 1995-1999
0	246	0.00	0.00
>0-5	62	33.16	0.53
>5-25	0	0.00	0.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	308	33.16	0.11

Lognormal parameters for positive doses in 1999:
μ: -0.8243
σ^2: 0.5826
Sample size: 7
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

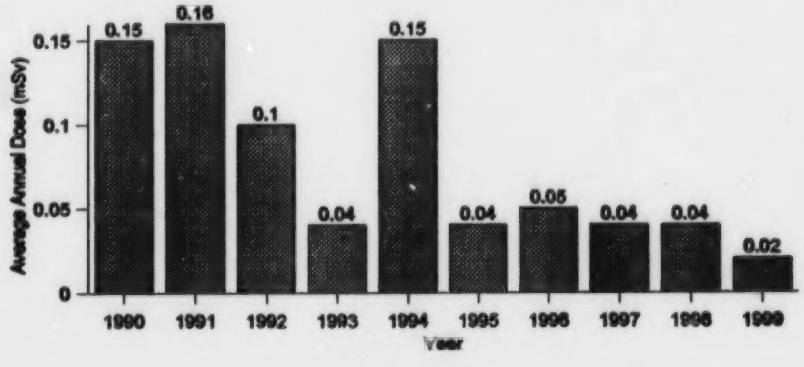


Table 4 (Cont'd)
Instrument Technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	1593	0.00	0.00
>0-1	248	95.01	0.38
>1-2	28	39.27	1.40
>2-5	20	70.14	3.51
>5-20	5	36.72	7.34
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	1894	241.14	0.13
			Five year period 1995-1999
0	1959	0.00	0.00
>0-5	965	928.12	0.96
>5-25	105	1029.09	9.80
>25-100	7	222.90	31.84
>100	0	0.00	0.00
Total	3036	2180.11	0.72

Lognormal parameters for positive doses in 1999:
μ: -0.7760
σ^2: 0.9316
Sample size: 301
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

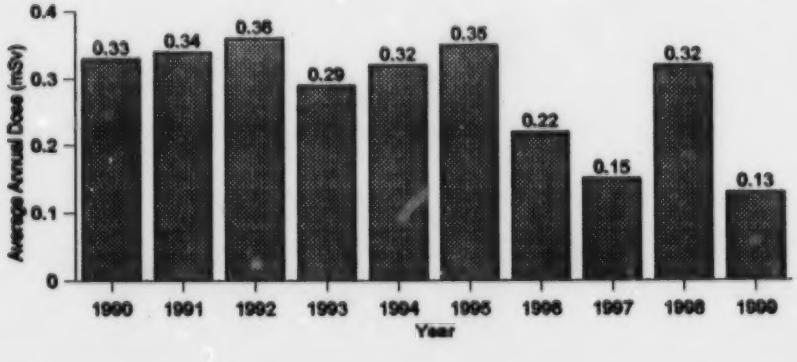


Table 4 (Cont'd)
Laboratory Technician (Industrial)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	2776	0.00	0.00
>0-1	409	154.03	0.38
>1-2	33	48.72	1.48
>2-5	30	90.28	3.01
>5-20	5	49.90	9.98
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	3253	342.93	0.11
			Five year period 1995-1999
0	4647	0.00	0.00
>0-5	2090	1610.00	0.77
>5-25	110	1105.57	10.05
>25-100	5	149.51	29.90
>100	0	0.00	0.00
Total	6852	2865.08	0.42

Lognormal parameters for positive doses in 1999:
μ: -0.8744
σ^2: 0.9176
Sample size: 477
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

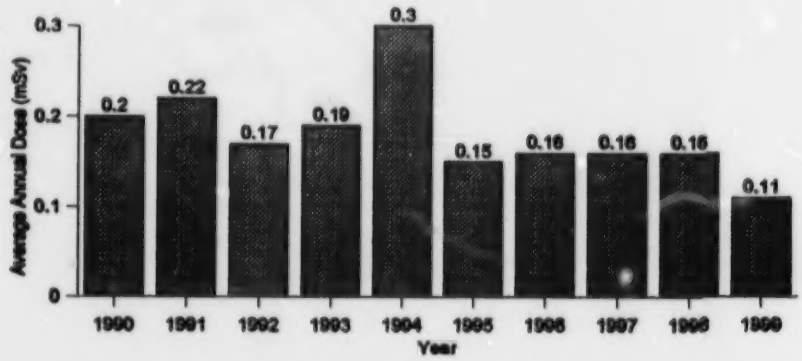


Table 4 (Cont'd)
Nuclear Fuel Processor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	46	0.00	0.00
>0-1	28	13.60	0.49
>1-2	17	25.00	1.47
>2-5	19	64.60	3.40
>5-20	10	75.00	7.50
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	120	178.20	1.49
			Five year period 1995-1999
0	42	0.00	0.00
>0-5	97	188.40	1.94
>5-25	72	946.25	13.14
>25-100	21	800.50	38.12
>100	0	0.00	0.00
Total	232	1935.15	8.34

Lognormal parameters for positive doses in 1999:
μ: +0.3392
σ^2: 1.2109
Sample size: 74
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

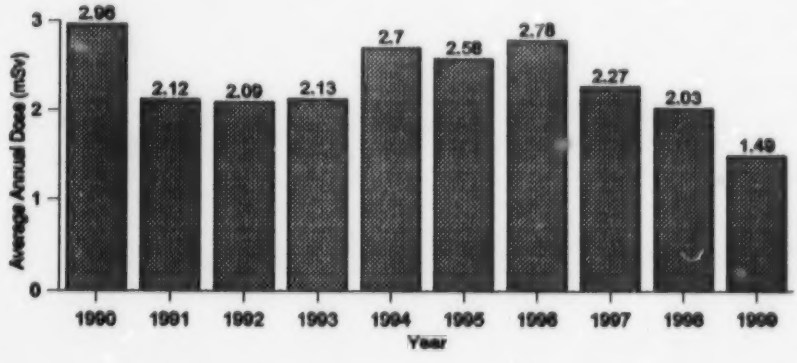


Table 4 (Cont'd)
Scientist/Engineer (Field)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	666	0.00	0.00
>0-1	476	175.47	0.37
>1-2	29	44.07	1.52
>2-5	13	38.00	2.92
>5-20	9	93.47	10.39
>20-50	2	61.90	30.95
>50	0	0.00	0.00
Total	1195	412.91	0.35
			Five year period 1995-1999
0	908	0.00	0.00
>0-5	1388	1583.82	1.14
>5-25	59	598.72	10.15
>25-100	6	214.14	35.69
>100	0	0.00	0.00
Total	2361	2396.68	1.02

Lognormal parameters for positive doses in 1999:
μ: -0.9880
σ^2: 1.0617
Sample size: 529
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

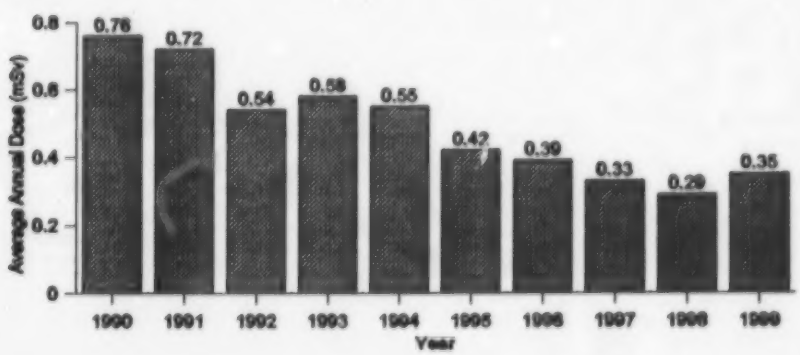


Table 4 (Cont'd)
Scientist/Engineer (Laboratory)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	4154	0.00	0.00
>0-1	147	45.62	0.31
>1-2	14	22.40	1.60
>2-5	2	4.50	2.25
>5-20	2	17.70	8.85
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	4319	90.22	0.02
			Five year period 1995-1999
0	6424	0.00	0.00
>0-5	2104	1058.70	0.50
>5-25	14	153.40	10.96
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	8542	1212.10	0.14

Lognormal parameters for positive doses in 1999:
μ: -1.0611
σ^2: 0.5844
Sample size: 165
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

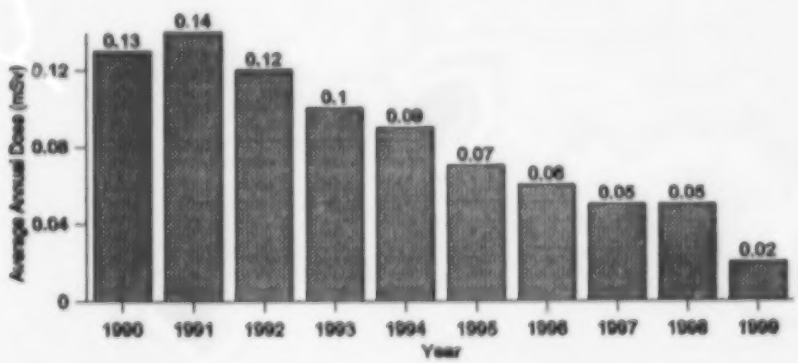


Table 4 (Cont'd)
Tradesman

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	29	0.00	0.00
>0-1	1	0.30	0.30
>1-2	0	0.00	0.00
>2-5	0	0.00	0.00
>5-20	0	0.00	0.00
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	30	0.30	0.01
			Five year period 1995-1999
0	29	0.00	0.00
>0-5	1	0.30	0.30
>5-25	0	0.00	0.00
>25-100	0	0.00	0.00
>100	0	0.00	0.00
Total	30	0.30	0.01

Lognormal or hybrid lognormal parameters for positive doses in 1999:
could not be calculated.
Sample size: 1
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

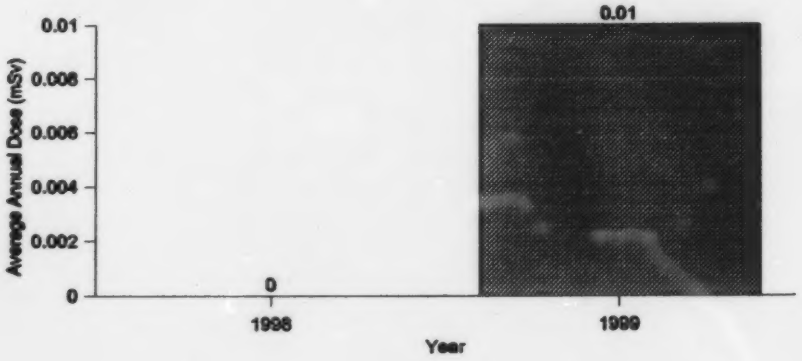


Table 4 (Cont'd)
Well Logger

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	343	0.00	0.00
>0-1	146	70.10	0.48
>1-2	37	56.20	1.52
>2-5	24	75.10	3.13
>5-20	13	83.70	6.44
>20-50	0	0.00	0.00
>50	0	0.00	0.00
Total	563	285.10	0.51
			Five year period 1995-1999
0	676	0.00	0.00
>0-5	832	957.59	1.15
>5-25	127	1120.10	8.82
>25-100	4	138.10	34.53
>100	0	0.00	0.00
Total	1639	2215.79	1.35

Lognormal parameters for positive doses in 1999:
μ: -0.2708
σ^2: 0.9507
Sample size: 220
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

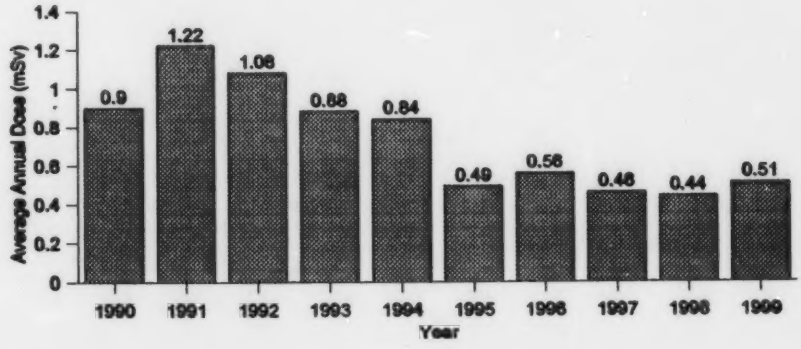


Table 4 (Cont'd)
Chiropractor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	946	.00	.00
>0-1	15	5.50	.37
>1-2	4	4.60	1.15
>2-5	1	3.90	3.90
>5-20	1	6.50	6.50
>20-50	0	.00	.00
>50	0	.00	.00
Total	967	20.50	.02
			Five year period 1995-1999
0	1143	.00	.00
>0-5	194	115.00	.59
>5-25	5	32.00	6.40
>25-100	2	58.40	29.20
>100	0	.00	.00
Total	1344	205.40	.15

Lognormal parameters for positive doses in 1999:
μ: -0.6381
σ^2: 0.9750
Sample size: 21
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

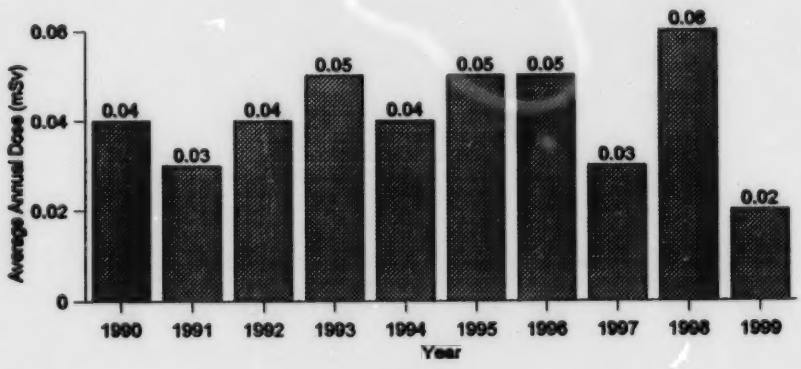


Table 4 (Cont'd)
Dental Assistant

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	9641	.00	.00
>0-1	105	31.60	.30
>1-2	2	3.30	1.65
>2-5	3	10.50	3.50
>5-20	2	14.10	7.05
>20-50	0	.00	.00
>50	0	.00	.00
Total	9753	59.50	.01
			Five year period 1995-1999
0	13370	.00	.00
>0-5	601	236.40	.39
>5-25	11	94.50	8.59
>25-100	0	.00	.00
>100	0	.00	.00
Total	13982	330.90	.02

Lognormal parameters for positive doses in 1999:
μ: -1.1360
σ^2: 0.5408
Sample size: 112
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

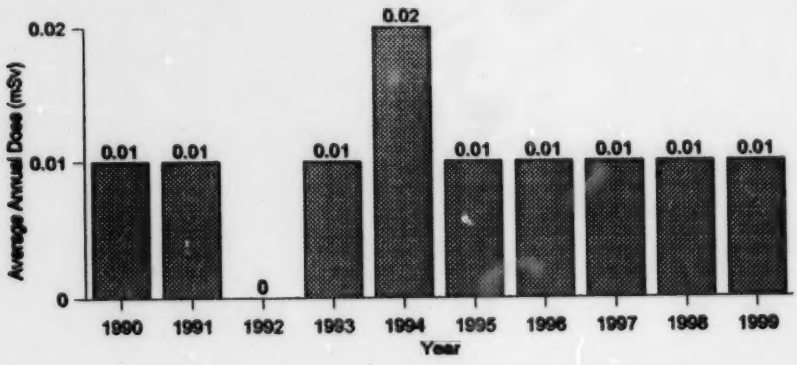


Table 4 (Cont'd)
Dental Hygienist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	7165	.00	.00
>0-1	79	25.00	.32
>1-2	0	.00	.00
>2-5	4	13.40	3.35
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	7248	38.40	.01
			Five year period 1995-1999
0	9527	.00	.00
>0-5	520	229.82	.44
>5-25	4	52.00	13.00
>25-100	0	.00	.00
>100	0	.00	.00
Total	10051	281.82	.03

Lognormal parameters for positive doses in 1999:
μ: -1.1281
σ^2: 0.4300
Sample size: 83
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

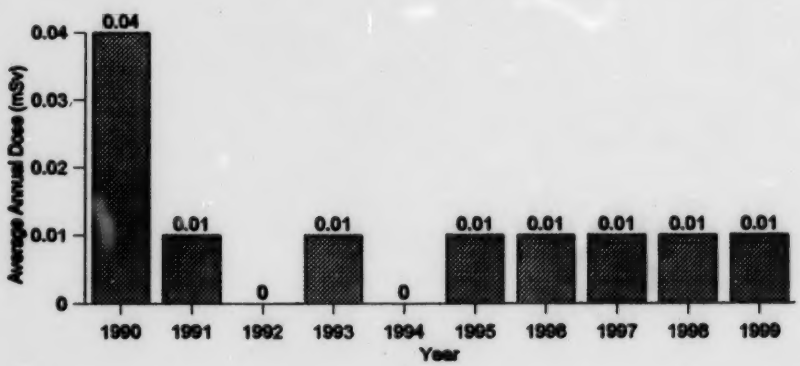


Table 4 (Cont'd)
Dental Therapist/Nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	87	.00	.00
>0-1	6	1.50	.25
>1-2	0	.00	.00
>2-5	0	.00	.00
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	93	1.50	.02
			Five year period 1995-1999
0	113	.00	.00
>0-5	13	5.60	.43
>5-25	0	.00	.00
>25-100	0	.00	.00
>100	0	.00	.00
Total	126	5.60	.04

Lognormal parameters for positive doses in 1999:
μ: -1.4263
σ^2: 0.0739
Sample size: 6
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

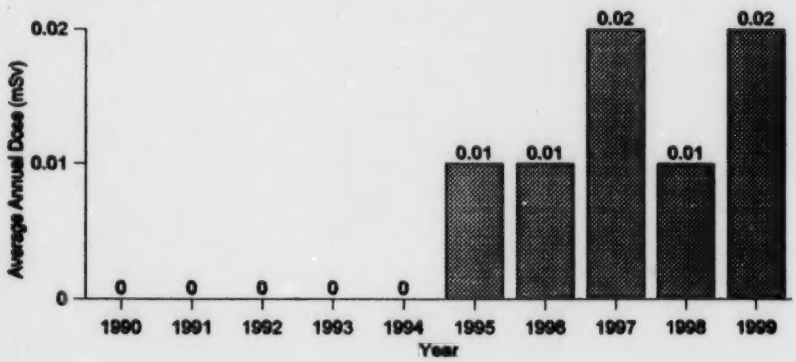


Table 4 (Cont'd)
Dentist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	6853	.00	.00
>0-1	105	31.90	.30
>1-2	2	3.30	1.65
>2-5	2	8.40	4.20
>5-20	0	.00	.00
>20-50	1	26.34	26.34
>50	0	.00	.00
Total	6963	69.94	.01
			Five year period 1995-1999
0	8002	.00	.00
>0-5	655	275.56	.42
>5-25	4	28.50	7.13
>25-100	1	26.34	26.34
>100	0	.00	.00
Total	8662	330.40	.04

Lognormal parameters for positive doses in 1999:
μ: -1.1658
σ^2: 0.5255
Sample size: 110
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

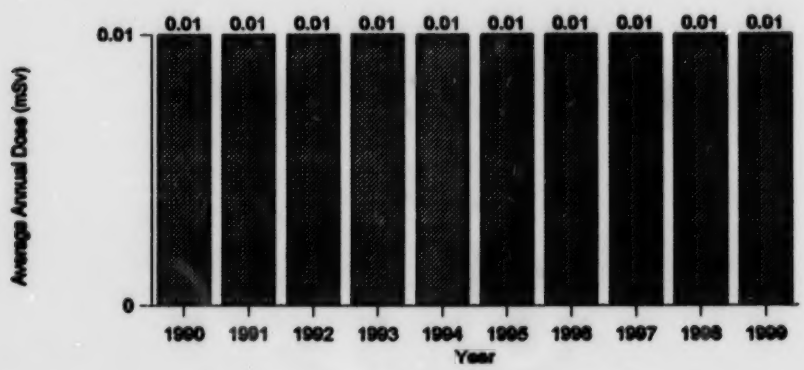


Table 4 (Cont'd)
Gynaecologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	17	.00	.00
>0-1	1	.20	.20
>1-2	0	.00	.00
>2-5	0	.00	.00
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	18	.20	.01
			Five year period 1995-1999
0	35	.00	.00
>0-5	11	10.60	.96
>5-25	0	.00	.00
>25-100	0	.00	.00
>100	0	.00	.00
Total	46	10.60	.23

Lognormal or hybrid lognormal parameters for positive doses in 1999:
could not be calculated.
Sample size: 1
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

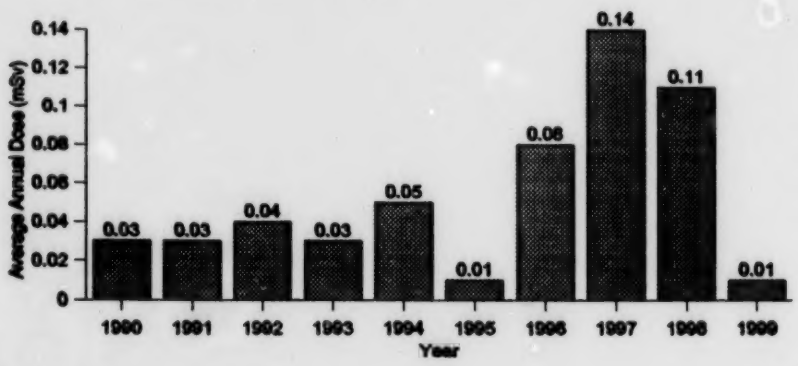


Table 4 (Cont'd)
Laboratory Technician (Medical)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	2545	.00	.00
>0-1	91	33.60	.37
>1-2	14	21.60	1.54
>2-5	13	39.40	3.03
>5-20	1	7.50	7.50
>20-50	0	.00	.00
>50	1	120.10	120.10
Total	2665	222.20	.08
			Five year period 1995-1999
0	4674	.00	.00
>0-5	1314	678.03	.52
>5-25	25	244.60	9.78
>25-100	2	73.00	36.50
>100	1	120.10	120.10
Total	6016	1115.73	.19

Lognormal parameters for positive doses in 1999:
μ: -0.6249
σ^2: 1.1034
Sample size: 120
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

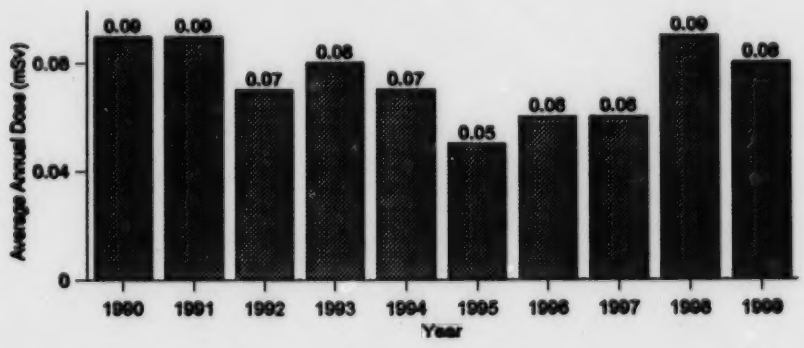


Table 4 (Cont'd)
Medical Physicist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	255	.00	.00
>0-1	10	3.51	.35
>1-2	1	1.10	1.10
>2-5	1	2.60	2.60
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	267	7.21	.03
			Five year period 1995-1999
0	286	.00	.00
>0-5	123	72.12	.59
>5-25	5	47.70	9.54
>25-100	1	41.80	41.80
>100	0	.00	.00
Total	415	161.62	.39

Lognormal parameters for positive doses in 1999:
μ: -0.8462
σ^2: 0.5297
Sample size: 12
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

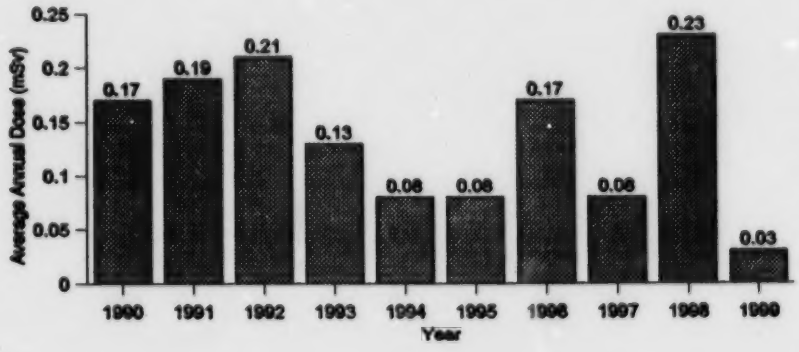


Table 4 (Cont'd)
Medical Radiation Technologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	9793	.00	.00
>0-1	643	220.10	.34
>1-2	55	81.80	1.49
>2-5	44	120.40	2.74
>5-20	1	15.90	15.90
>20-50	2	69.00	34.50
>50	0	.00	.00
Total	10538	507.20	.05
			Five year period 1995-1999
0	9186	.00	.00
>0-5	5648	3639.25	.64
>5-25	86	787.40	9.16
>25-100	7	255.10	36.44
>100	0	.00	.00
Total	14927	4681.75	.31

Lognormal parameters for positive doses in 1999:
μ: -0.9291
σ^2: 0.6626
Sample size: 745
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

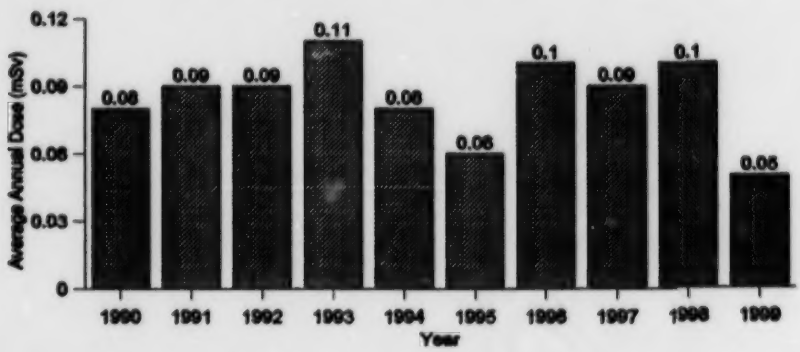


Table 4 (Cont'd)
Nuclear Medicine Technologist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	420	.00	.00
>0-1	262	156.00	.60
>1-2	204	316.80	1.55
>2-5	303	956.20	3.16
>5-20	33	227.80	6.90
>20-50	0	.00	.00
>50	0	.00	.00
Total	1222	1656.80	1.36
			Five year period 1995-1999
0	463	.00	.00
>0-5	822	1647.47	2.00
>5-25	649	6805.30	10.49
>25-100	15	558.60	37.24
>100	0	.00	.00
Total	1949	9011.37	4.62

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.2012
μ: -0.7878
σ^2: 1.3658
Sample size: 802
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

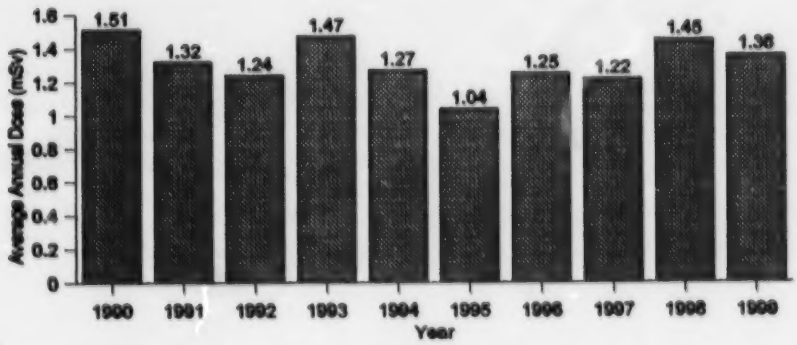


Table 4 (Cont'd)
Nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	3447	.00	.00
>0-1	246	86.02	.35
>1-2	31	44.30	1.43
>2-5	8	21.10	2.64
>5-20	1	5.50	5.50
>20-50	0	.00	.00
>50	0	.00	.00
Total	3733	156.92	.04
			Five year period 1995-1999
0	5569	.00	.00
>0-5	2558	2208.61	.86
>5-25	28	231.30	8.26
>25-100	0	.00	.00
>100	0	.00	.00
Total	8155	2439.91	.30

Lognormal parameters for positive doses in 1999:
μ: -0.9430
σ^2: 0.5477
Sample size: 286
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

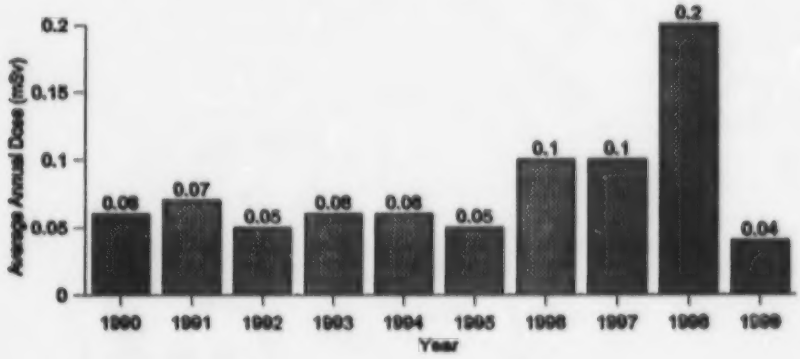


Table 4 (Cont'd)
Physician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	1438	.00	.00
>0-1	157	64.30	.41
>1-2	28	40.80	1.46
>2-5	17	49.50	2.91
>5-20	6	39.80	6.63
>20-50	0	.00	.00
>50	0	.00	.00
Total	1646	194.40	.12
			Five year period 1995-1999
0	1770	.00	.00
>0-5	1118	980.20	.88
>5-25	58	543.00	9.36
>25-100	5	216.10	43.22
>100	0	.00	.00
Total	2951	1739.30	.59

Lognormal parameters for positive doses in 1999:
μ: -0.5913
σ^2: 0.8730
Sample size: 208
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

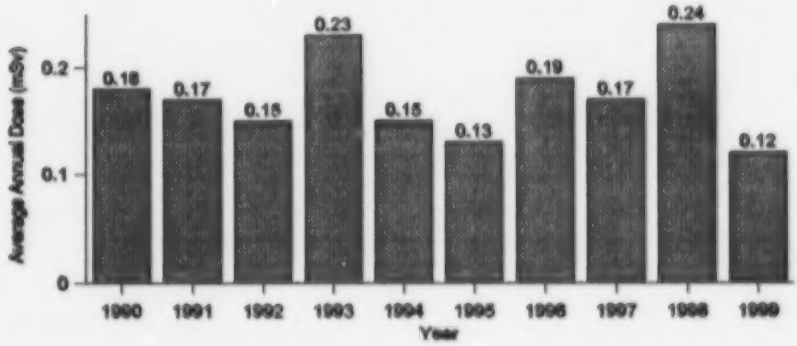


Table 4 (Cont'd)
Radiation Therapist

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	882	.00	.00
>0-1	112	41.40	.37
>1-2	9	12.80	1.42
>2-5	6	18.10	3.02
>5-20	3	25.40	8.47
>20-50	1	21.80	21.80
>50	0	.00	.00
Total	1013	119.50	.12
			Five year period 1995-1999
0	704	.00	.00
>0-5	732	519.60	.71
>5-25	19	215.50	11.34
>25-100	2	103.40	51.70
>100	0	.00	.00
Total	1457	836.50	.58

Lognormal parameters for positive doses in 1999:
μ: -0.8384
σ^2: 0.9002
Sample size: 131
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

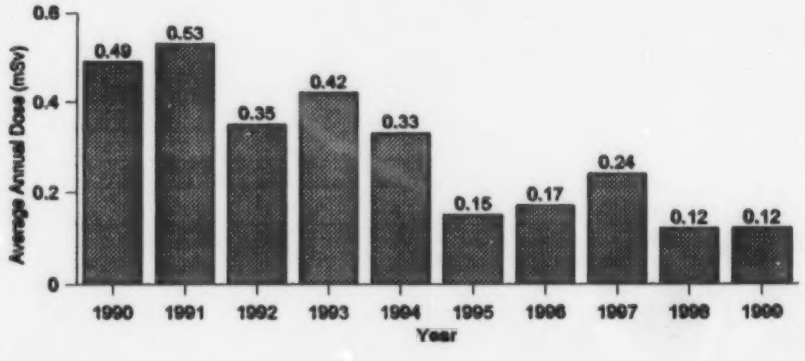


Table 4 (Cont'd)
Radiologist (Diagnostic)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	1336	.00	.00
>0-1	149	61.00	.41
>1-2	19	27.30	1.44
>2-5	9	25.60	2.84
>5-20	8	79.31	9.91
>20-50	0	.00	.00
>50	0	.00	.00
Total	1521	193.21	.13
			Five year period 1995-1999
0	1299	.00	.00
>0-5	982	790.60	.81
>5-25	36	345.01	9.58
>25-100	2	61.00	30.50
>100	0	.00	.00
Total	2319	1196.61	.52

Lognormal parameters for positive doses in 1999:
μ: -0.6676
σ^2: 0.9666
Sample size: 185
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

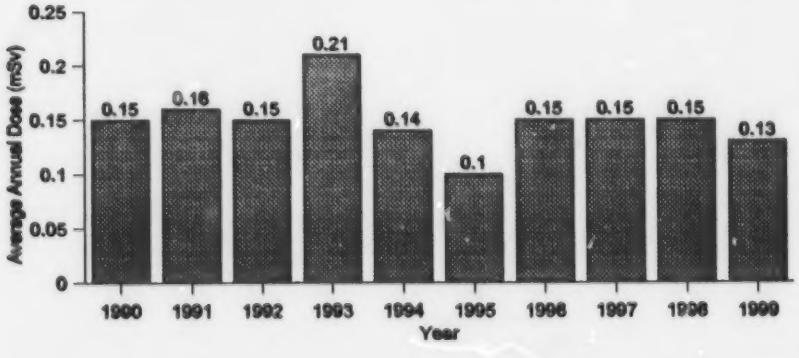


Table 4 (Cont'd)
Radiologist (Therapeutic)

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	153	.00	.00
>0-1	15	6.50	.43
>1-2	0	.00	.00
>2-5	0	.00	.00
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	168	6.50	.04
			Five year period 1995-1999
0	190	.00	.00
>0-5	86	47.10	.55
>5-25	1	9.30	9.30
>25-100	0	.00	.00
>100	0	.00	.00
Total	277	56.40	.20

Lognormal parameters for positive doses in 1999:
μ: -0.9624
σ^2: 0.2391
Sample size: 15
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

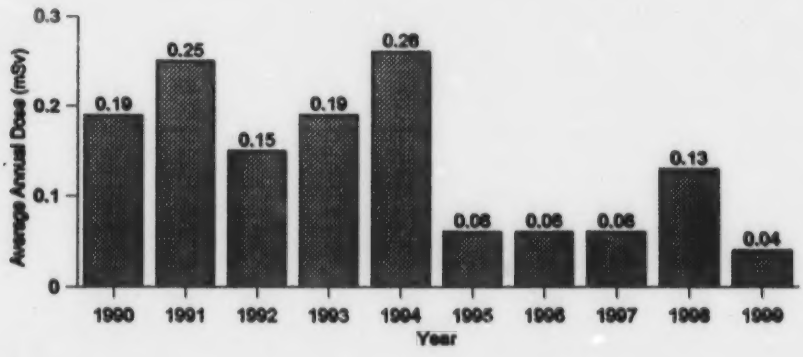


Table 4 (Cont'd)
Veterinarian

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	3806	.00	.00
>0-1	199	66.24	.33
>1-2	12	17.90	1.49
>2-5	2	6.70	3.35
>5-20	1	6.80	6.80
>20-50	0	.00	.00
>50	0	.00	.00
Total	4020	97.64	.02
			Five year period 1995-1999
0	4632	.00	.00
>0-5	1207	614.98	.51
>5-25	18	129.30	7.18
>25-100	2	60.60	30.30
>100	0	.00	.00
Total	5859	804.88	.14

Lognormal parameters for positive doses in 1999:
μ: -1.0859
σ^2: 0.4167
Sample size: 214
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

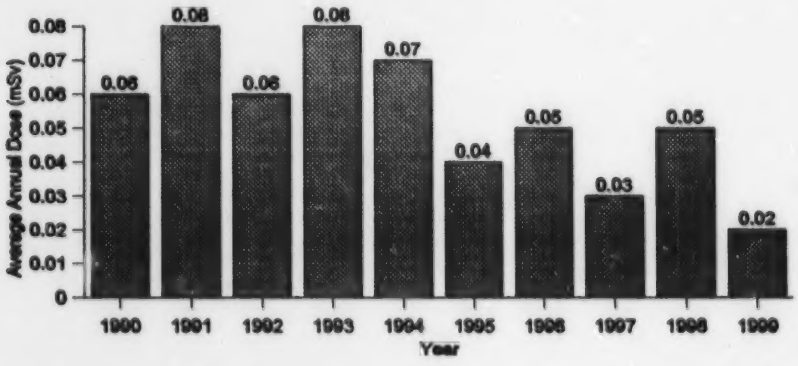


Table 4 (Cont'd)
Veterinary Technician

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	785	.00	.00
>0-1	30	12.20	.41
>1-2	1	1.90	1.90
>2-5	0	.00	.00
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	816	14.10	.02
			Five year period 1995-1999
0	802	.00	.00
>0-5	53	32.70	.62
>5-25	0	.00	.00
>25-100	0	.00	.00
>100	0	.00	.00
Total	855	32.70	.04

Lognormal parameters for positive doses in 1999:
μ: -1.0008
σ^2: 0.3800
Sample size: 31
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

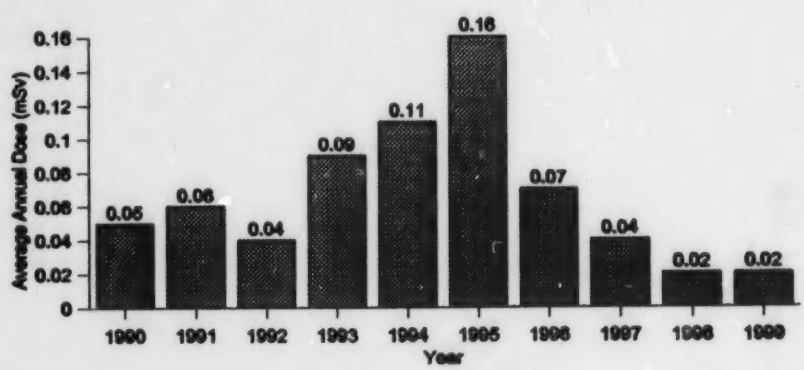


Table 4 (Cont'd)
Ward Aid/Orderly

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose
			Year 1999
0	1395	.00	.00
>0-1	66	21.80	.33
>1-2	4	6.20	1.55
>2-5	6	20.50	3.42
>5-20	0	.00	.00
>20-50	0	.00	.00
>50	0	.00	.00
Total	1471	48.50	.03
			Five year period 1995-1999
0	2354	.00	.00
>0-5	604	419.60	.69
>5-25	10	98.90	9.89
>25-100	2	99.70	49.85
>100	0	.00	.00
Total	2970	618.20	.21

Lognormal parameters for positive doses in 1999:
μ: -0.9543
σ^2: 0.7301
Sample size: 76
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

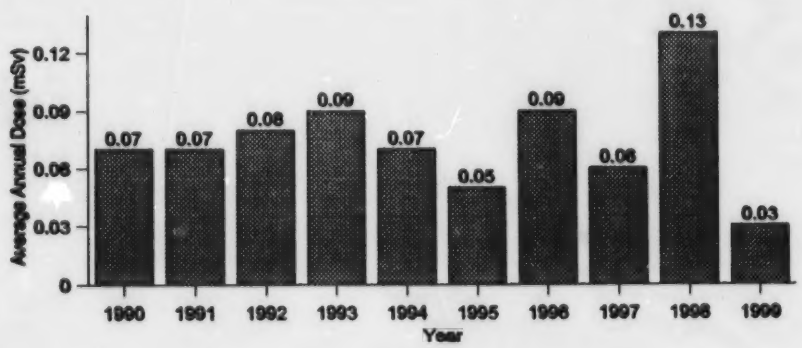


Table 4 (Cont'd)
Reactor-Administration

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	3616	0.00	0.00	0
>0-1	584	172.38	0.30	45
>1-2	139	204.45	1.47	40
>2-5	109	325.58	2.99	34
>5-20	50	358.56	7.17	21
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	4498	1060.97	0.24	33
				Five year period 1995-1999
0	4653	0.00	0.00	0
>0-5	2186	2174.46	0.99	35
>5-25	325	2984.03	9.18	27
>25-100	2	61.24	30.62	11
>100	0	0.00	0.00	0
Total	7166	5219.73	0.73	30

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.1744
μ: -2.4397
σ^2: 3.6723
Sample size: 882
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

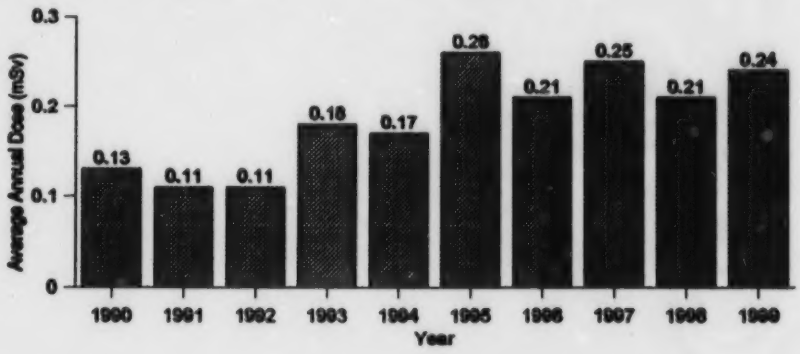


Table 4 (Cont'd)
Reactor-Chemical and Radiation Control

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	92	0.00	0.00	0
>0-1	156	60.10	0.39	45
>1-2	31	43.44	1.40	34
>2-5	41	128.27	3.13	15
>5-20	38	333.62	8.78	10
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	358	565.43	1.58	17
				Five year period 1995-1999
0	152	0.00	0.00	0
>0-5	259	373.16	1.44	45
>5-25	110	1173.14	10.66	22
>25-100	41	1794.99	43.78	9
>100	0	0.00	0.00	0
Total	562	3341.29	5.95	17

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.0975
μ: -2.4388
σ^2: 3.5764
Sample size: 266
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

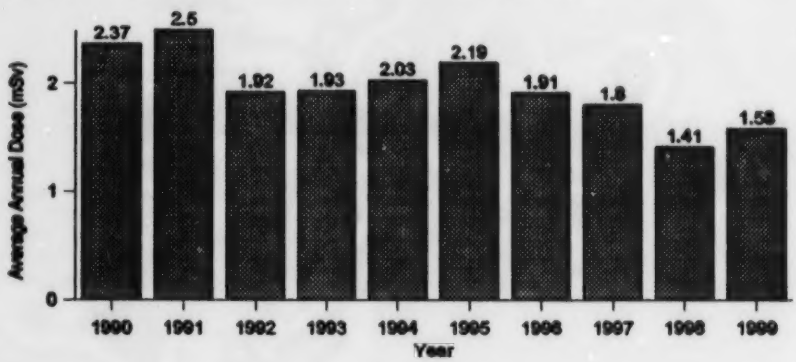


Table 4 (Cont'd)
Reactor-Construction

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	756	0.00	0.00	0
>0-1	314	95.52	0.30	23
>1-2	126	184.57	1.46	14
>2-5	176	578.41	3.29	12
>5-20	226	2051.43	9.08	8
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1598	2909.93	1.82	10
				Five year period 1995-1999
0	1233	0.00	0.00	0
>0-5	957	1443.58	1.51	16
>5-25	585	7218.54	12.34	10
>25-100	133	4897.72	36.82	11
>100	0	0.00	0.00	0
Total	2908	13559.84	4.66	11

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.2569
μ: -0.2587
σ^2: 7.2067
Sample size: 842
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

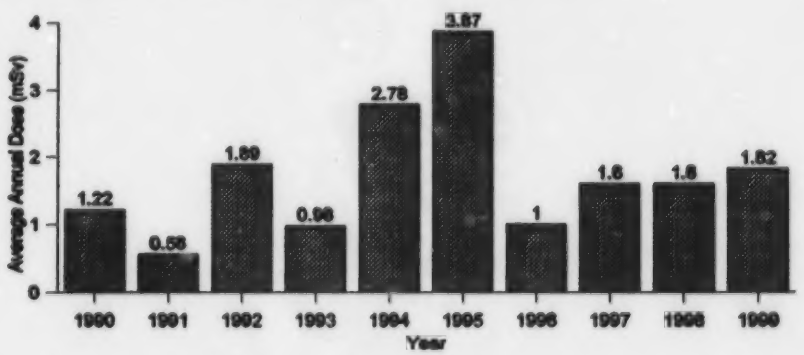


Table 4 (Cont'd)
Reactor-Control Technicians

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	55	0.00	0.00	0
>0-1	36	10.40	0.29	47
>1-2	17	24.39	1.43	27
>2-5	18	62.38	3.47	21
>5-20	7	64.88	9.27	4
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	133	162.05	1.22	17
				Five year period 1995-1999
0	76	0.00	0.00	0
>0-5	75	114.75	1.53	25
>5-25	45	489.65	10.88	21
>25-100	8	235.44	29.43	11
>100	0	0.00	0.00	0
Total	204	839.84	4.12	19

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.2417
μ: -1.1949
σ^2: 5.0800
Sample size: 78
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

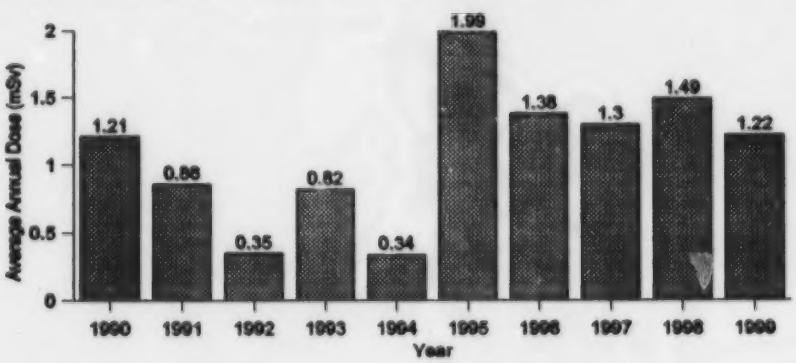


Table 4 (Cont'd)
Reactor-Electrical Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	397	0.00	0.00	0
>0-1	281	90.79	0.32	35
>1-2	129	184.57	1.43	21
>2-5	136	451.32	3.32	17
>5-20	43	297.20	6.91	12
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	986	1023.88	1.04	18
				Five year period 1995-1999
0	317	0.00	0.00	0
>0-5	704	1110.99	1.58	27
>5-25	408	4296.35	10.53	22
>25-100	26	784.16	30.16	13
>100	0	0.00	0.00	0
Total	1455	6191.50	4.26	22

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.4105
μ: -0.4901
σ^2: 5.2847
Sample size: 589
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

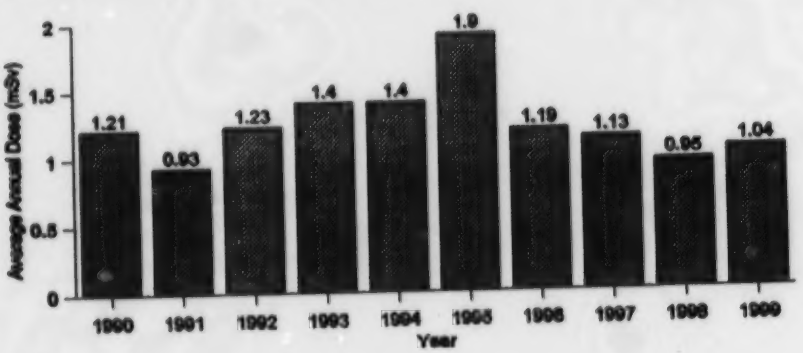


Table 4 (Cont'd)
Reactor-Fuel Handling

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	1	0.00	0.00	0
>0-1	9	2.87	0.32	25
>1-2	1	1.41	1.41	12
>2-5	11	37.24	3.39	13
>5-20	23	242.64	10.55	18
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	45	284.16	6.31	18
				Five year period 1995-1999
0	11	0.00	0.00	0
>0-5	58	101.02	1.74	18
>5-25	104	1172.05	11.27	16
>25-100	17	734.17	43.19	27
>100	0	0.00	0.00	0
Total	190	2007.24	10.56	20

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.5507
μ: +4.1519
σ^2: 17.0509
Sample size: 44
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

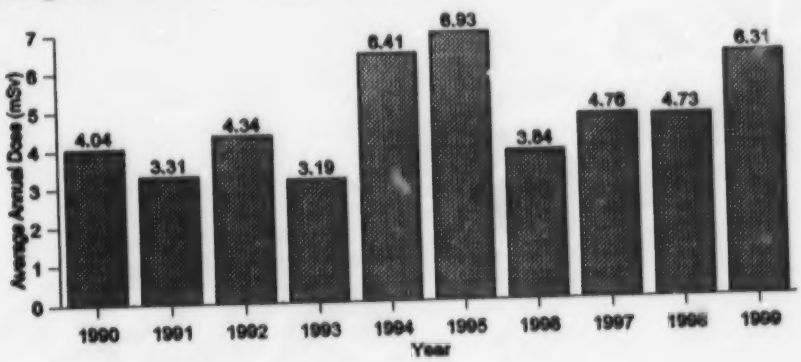


Table 4 (Cont'd)
Reactor-General Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	771	0.00	0.00	0
>0-1	281	93.71	0.33	27
>1-2	62	90.45	1.46	23
>2-5	86	292.10	3.40	17
>5-20	100	866.24	8.66	11
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1300	1342.50	1.03	14
				Five year period 1995-1999
0	1186	0.00	0.00	0
>0-5	786	994.39	1.27	30
>5-25	316	3593.84	11.37	19
>25-100	52	1708.83	32.86	13
>100	0	0.00	0.00	0
Total	2340	6297.06	2.69	19

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.1692
μ: -1.5711
σ^2: 5.1930
Sample size: 529
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

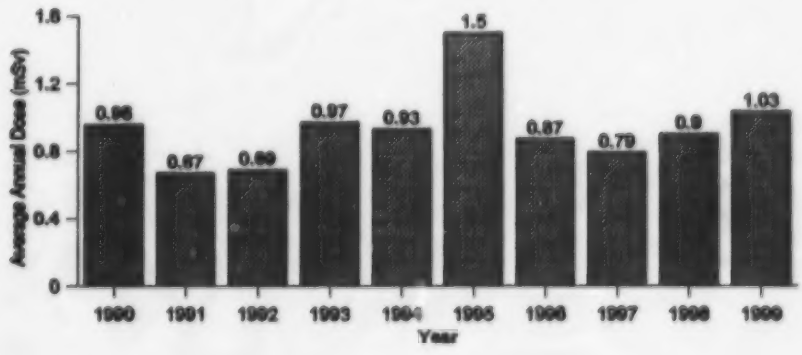


Table 4 (Cont'd)
Reactor-Health Physics

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	46	0.00	0.00	0
>0-1	18	4.01	0.22	38
>1-2	3	4.54	1.51	26
>2-5	9	29.44	3.27	12
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	76	37.99	0.50	18
				Five year period 1995-1999
0	94	0.00	0.00	0
>0-5	47	40.24	0.86	24
>5-25	18	218.96	12.16	24
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	159	259.20	1.63	24

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.4318
μ: -1.1362
σ^2: 5.2496
Sample size: 30
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

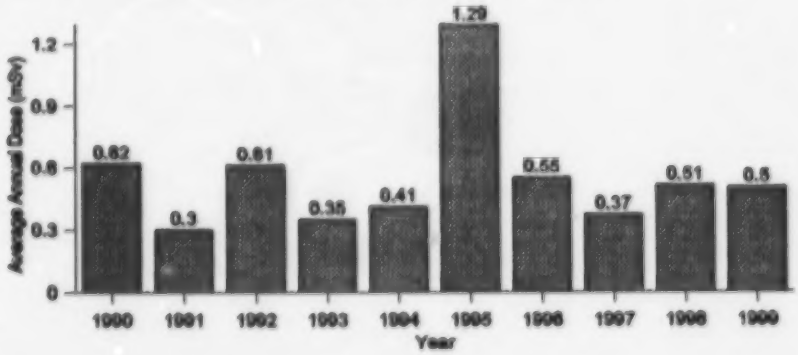


Table 4 (Cont'd)
Reactor-Industrial Radiographer

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	5	0.00	0.00	0
>0-1	1	0.60	0.60	0
>1-2	3	4.37	1.46	10
>2-5	5	15.45	3.09	14
>5-20	3	20.72	6.91	4
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	17	41.14	2.42	8
				Five year period 1995-1999
0	9	0.00	0.00	0
>0-5	13	27.28	2.10	9
>5-25	16	178.62	11.16	5
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	38	205.90	5.42	6

Lognormal parameters for positive doses in 1999:
μ: +0.9728
σ^2: 0.5573
Sample size: 12
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

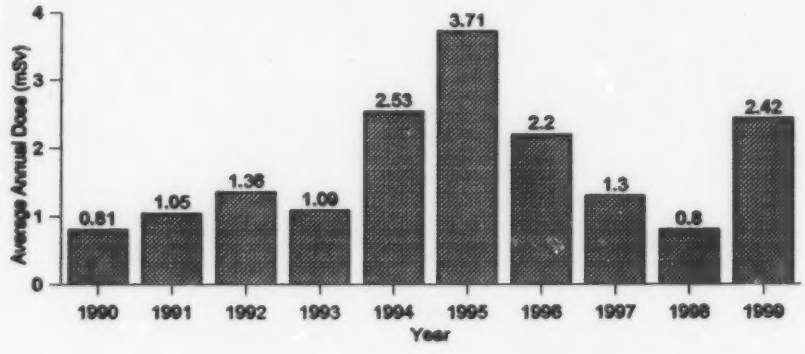


Table 4 (Cont'd)
Reactor-Mechanical Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	348	0.00	0.00	0
>0-1	303	107.86	0.36	35
>1-2	139	206.20	1.48	25
>2-5	227	747.98	3.30	17
>5-20	273	2202.63	8.07	11
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1290	3264.67	2.53	14
				Five year period 1995-1999
0	508	0.00	0.00	0
>0-5	782	1352.53	1.73	23
>5-25	822	9974.57	12.13	19
>25-100	202	6977.64	34.54	15
>100	0	0.00	0.00	0
Total	2314	18304.74	7.91	17

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.3918
μ: +0.8269
σ^2: 8.2349
Sample size: 942
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

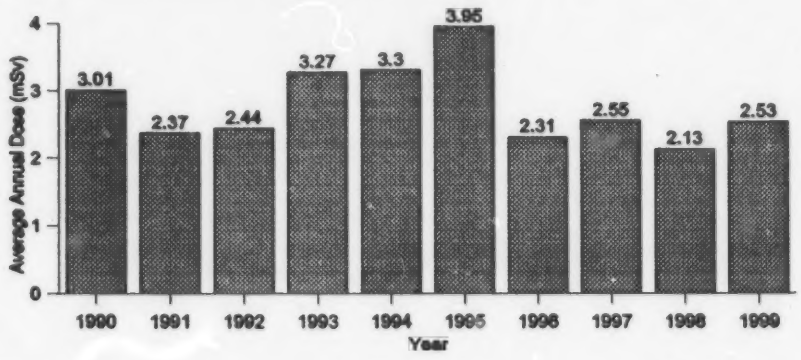


Table 4 (Cont'd)
Reactor-Operations

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	676	0.00	0.00	0
>0-1	725	259.64	0.36	50
>1-2	222	316.14	1.42	48
>2-5	185	579.52	3.13	37
>5-20	120	1059.98	8.83	15
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1928	2215.28	1.15	30
				Five year period 1995-1999
0	432	0.00	0.00	0
>0-5	1056	1537.46	1.46	41
>5-25	700	7785.39	11.12	40
>25-100	106	4101.12	38.69	14
>100	0	0.00	0.00	0
Total	2294	13423.97	5.85	32

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.1189
μ: -2.3931
σ^2: 3.5656
Sample size: 1252
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

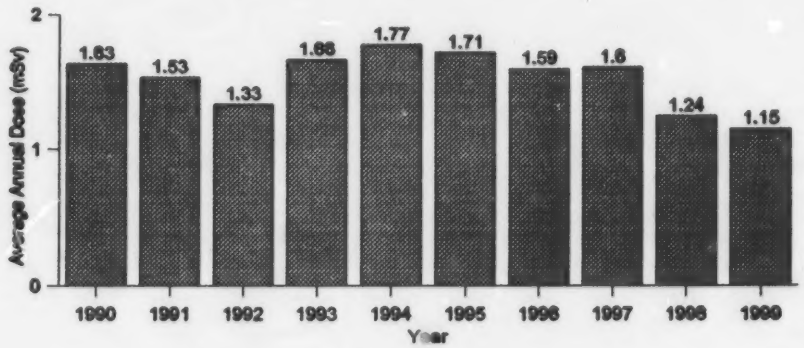


Table 4 (Cont'd)
Reactor-Scientific/Professional

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	1153	0.00	0.00	0
>0-1	223	74.10	0.33	20
>1-2	47	70.08	1.49	15
>2-5	70	222.04	3.17	14
>5-20	59	477.65	8.10	10
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	1552	843.87	0.54	12
				Five year period 1995-1999
0	1979	0.00	0.00	0
>0-5	721	740.97	1.03	19
>5-25	254	2711.44	10.67	13
>25-100	56	2119.82	37.85	11
>100	0	0.00	0.00	0
Total	3010	5572.23	1.85	13

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.1736
μ: -1.7617
σ^2: 4.7667
Sample size: 399
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

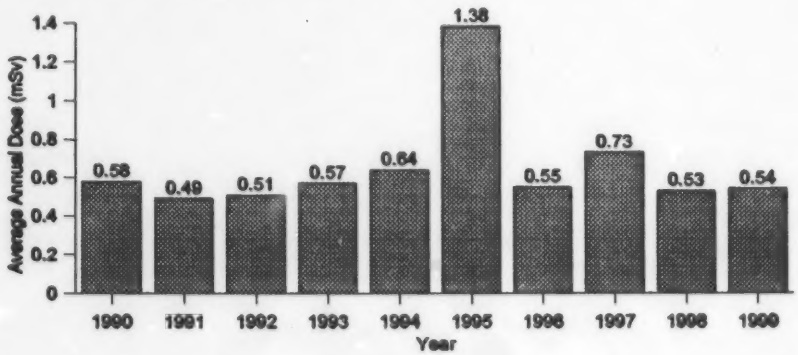


Table 4 (Cont'd)
Reactor-Training

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	68	0.00	0.00	0
>0-1	11	2.83	0.26	28
>1-2	5	6.21	1.24	36
>2-5	2	8.04	4.02	14
>5-20	7	60.46	8.64	8
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	93	77.54	0.83	12
				Five year period 1995-1999
0	109	0.00	0.00	0
>0-5	36	25.27	0.70	26
>5-25	9	103.08	11.45	12
>25-100	1	49.36	49.36	12
>100	0	0.00	0.00	0
Total	155	177.71	1.15	14

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.1798
μ: -1.2844
σ^2: 6.4089
Sample size: 25
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

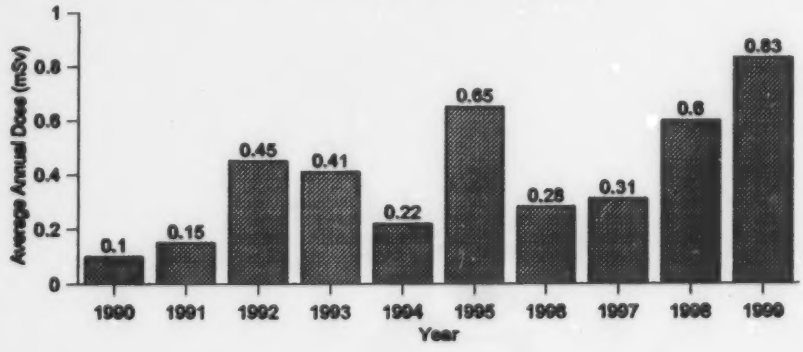


Table 4 (Cont'd)
Reactor-Visitor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Tritium
				Year 1999
0	2357	0.00	0.00	0
>0-1	110	31.81	0.29	26
>1-2	45	68.32	1.52	11
>2-5	67	221.08	3.30	10
>5-20	87	728.63	8.38	9
>20-50	1	21.88	21.88	8
>50	0	0.00	0.00	0
Total	2667	1071.72	0.40	10
				Five year period 1995-1999
0	2494	0.00	0.00	0
>0-5	366	490.28	1.34	10
>5-25	298	3716.68	12.47	5
>25-100	12	400.10	33.34	10
>100	0	0.00	0.00	0
Total	3170	4607.06	1.45	5

Lognormal parameters for positive doses in 1999:
ρ: 0.3234
μ: +0.2458
σ^2: 8.0932
Sample size: 310
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

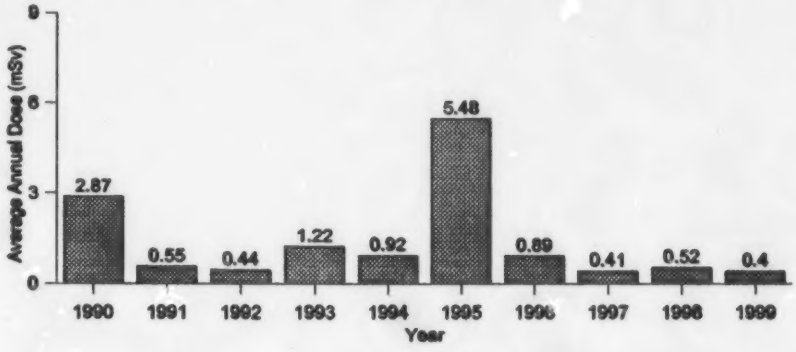


Table 4 (Cont'd)
Uranium Mine Mill Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	9	0.00	0.00	0
>0-1	57	29.95	0.53	74
>1-2	35	49.75	1.42	68
>2-5	45	131.60	2.92	47
>5-20	1	5.20	5.20	21
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	147	216.50	1.47	55
				Five year period 1995-1999
0	33	0.00	0.00	0
>0-5	162	255.25	1.58	67
>5-25	96	1028.55	10.71	44
>25-100	6	161.90	26.98	24
>100	0	0.00	0.00	0
Total	297	1445.70	4.87	46

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.9404
μ: +1.4617
σ^2: 4.3655
Sample size: 138
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

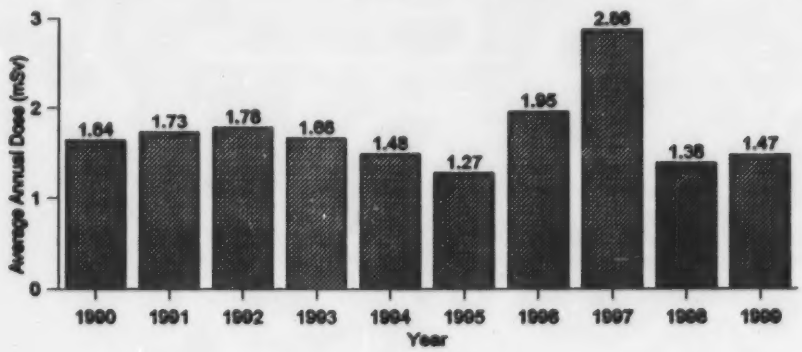


Table 4 (Cont'd)
Uranium Mine Mill Worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	21	0.00	0.00	0
>0-1	53	28.00	0.53	71
>1-2	37	56.95	1.54	48
>2-5	74	230.25	3.11	51
>5-20	4	22.40	5.60	58
>20-50	0	0 00	0.00	0
>50	0	0.00	0.00	0
Total	189	337.60	1.79	53
				Five year period 1995-1999
0	21	0.00	0.00	0
>0-5	202	278.50	1.38	52
>5-25	160	1793.05	11.21	44
>25-100	6	158.25	26.38	27
>100	0	0.00	0.00	0
Total	389	2229.80	5.73	44

Hybrid lognormal parameters for positive doses in 1999:
ρ: 1.1184
μ: +2.6868
σ^2: 6.2310
Sample size: 168
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

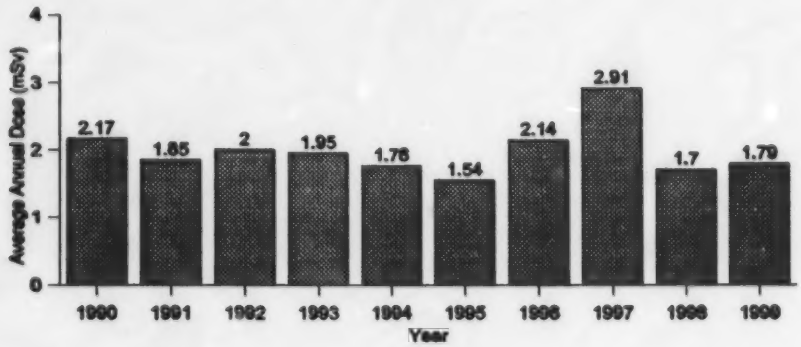


Table 4 (Cont'd)
Uranium Mine Nurse

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	17	0.00	0.00	0
>0-1	5	1.05	0.21	71
>1-2	0	0.00	0.00	0
>2-5	0	0.00	0.00	0
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	22	1.05	0.05	71
				Five year period 1995-1999
0	22	0.00	0.00	0
>0-5	9	4.60	0.51	83
>5-25	0	0.00	0.00	0
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	31	4.60	0.15	83

Lognormal parameters for positive doses in 1999:
μ: -1.6223
σ^2 0.1388
Sample size: 5
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

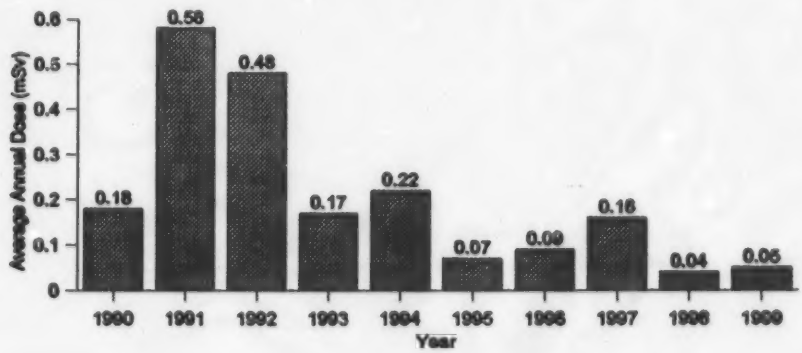


Table 4 (Cont'd)
Uranium Mine Office Staff

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	57	0.00	0.00	0
>0-1	108	28.75	0.27	53
>1-2	1	1.10	1.10	18
>2-5	0	0.00	0.00	0
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	166	29.85	0.18	52
				Five year period 1995-1999
0	109	0.00	0.00	0
>0-5	215	179.60	0.84	66
>5-25	2	14.05	7.03	60
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	326	193.65	0.59	66

Lognormal parameters for positive doses in 1999:
μ: -1.5755
σ^2: 0.5783
Sample size: 109
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

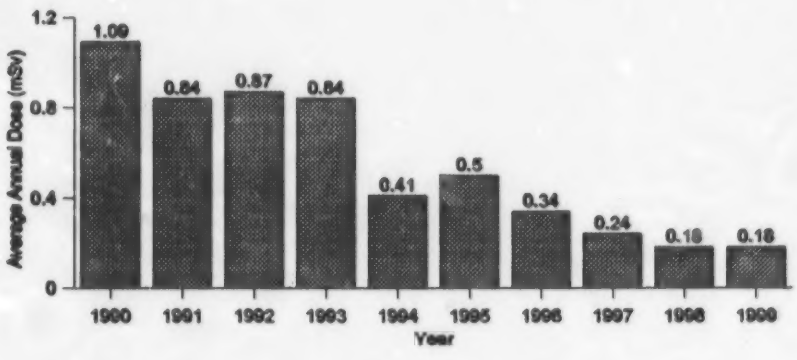


Table 4 (Cont'd)
Uranium Mine Support Worker

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	57	0.00	0.00	0
>0-1	239	92.20	0.39	80
>1-2	71	103.90	1.46	73
>2-5	90	293.00	3.26	77
>5-20	9	53.55	5.95	54
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	466	542.65	1.16	74
				Five year period 1995-1999
0	85	0.00	0.00	0
>0-5	536	680.12	1.27	74
>5-25	145	1631.25	11.25	56
>25-100	8	256.60	32.08	34
>100	0	0.00	0.00	0
Total	774	2567.97	3.32	58

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.2942
μ: -1.2306
σ^2: 2.7930
Sample size: 409
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

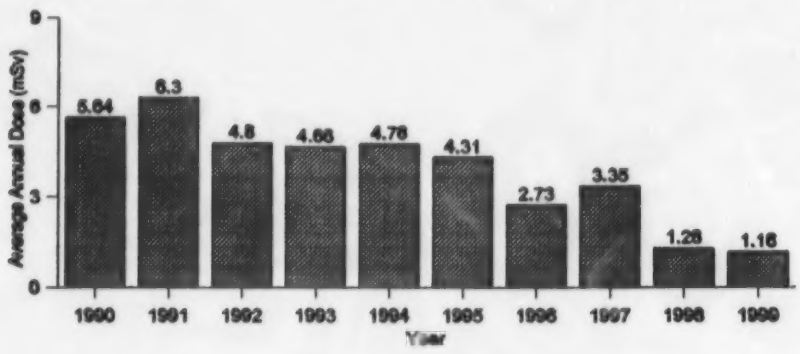


Table 4 (Cont'd)
Uranium Mine Surface Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	50	0.00	0.00	0
>0-1	144	46.05	0.32	72
>1-2	19	26.25	1.38	78
>2-5	6	16.10	2.68	70
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	219	88.40	0.40	73
				Five year period 1995-1999
0	121	0.00	0.00	0
>0-5	396	498.05	1.26	65
>5-25	22	153.10	6.96	65
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	539	651.15	1.21	65

Lognormal parameters for positive doses in 1999:
μ: -1.2095
σ^2: 1.1806
Sample size: 169
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

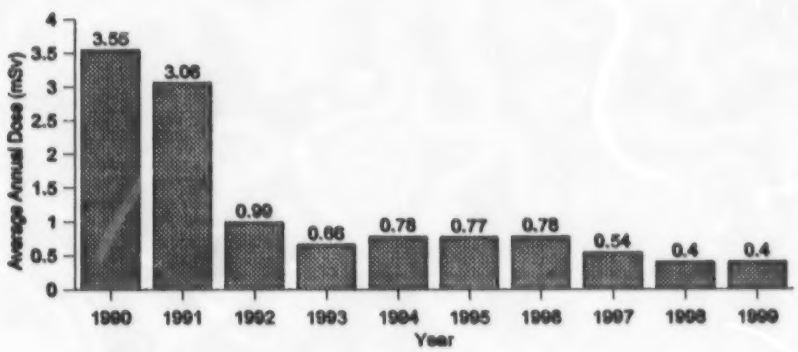


Table 4 (Cont'd)
Uranium Mine Surface Miner

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	12	0.00	0.00	0
>0-1	38	16.75	0.44	21
>1-2	15	21.25	1.42	8
>2-5	9	23.65	2.63	6
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	74	61.65	0.83	11
				Five year period 1995-1999
0	53	0.00	0.00	0
>0-5	234	271.50	1.16	39
>5-25	58	493.85	8.51	24
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	345	765.35	2.22	29

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.5643
μ: -0.4535
σ^2: 2.1710
Sample size: 62
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

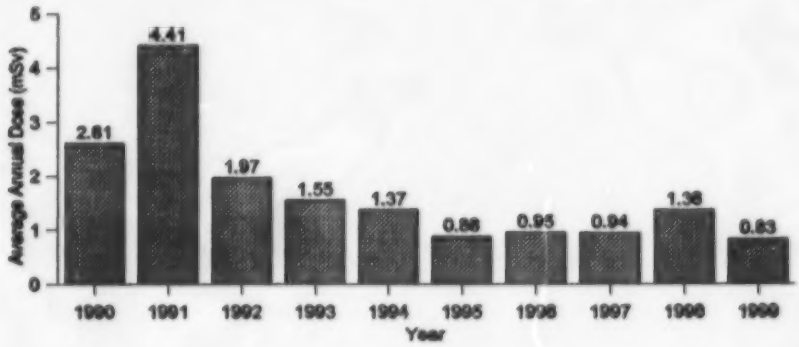


Table 4 (Cont'd)
Uranium Mine Surface Personnel

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	57	0.00	0.00	0
>0-1	103	34.90	0.34	62
>1-2	14	18.75	1.34	66
>2-5	3	8.70	2.90	49
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	177	62.35	0.35	62
				Five year period 1995-1999
0	79	0.00	0.00	0
>0-5	185	153.35	0.83	65
>5-25	5	45.45	9.09	58
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	269	198.80	0.74	63

Lognormal parameters for positive doses in 1999:
μ: -1.1306
σ^2: 1.0068
Sample size: 120
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

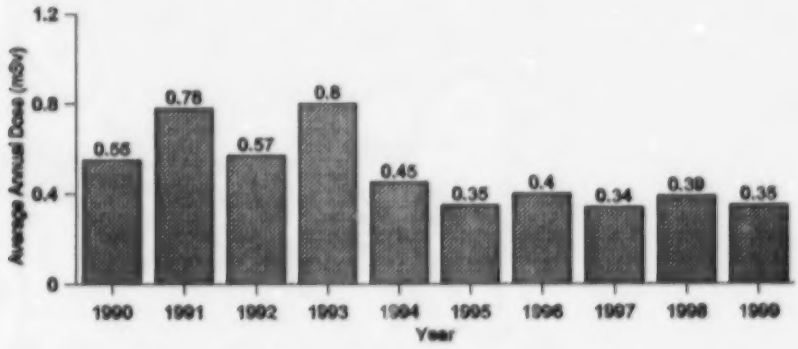


Table 4 (Cont'd)
Uranium Mine Surface Support Workers

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	75	0.00	0.00	0
>0-1	141	45.20	0.32	38
>1-2	8	10.80	1.35	55
>2-5	5	12.10	2.42	53
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	229	68.10	0.30	44
				Five year period 1995-1999
0	286	0.00	0.00	0
>0-5	444	486.80	1.10	53
>5-25	29	255.60	8.81	42
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	759	742.40	0.98	49

Lognormal parameters for positive doses in 1999:
μ: -1.2752
σ^2: 0.9196
Sample size: 154
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

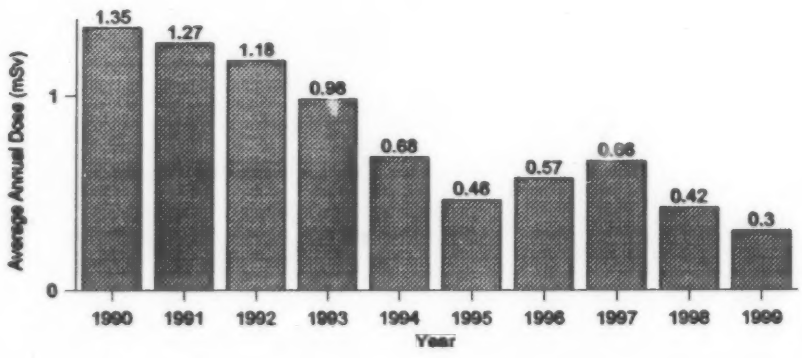


Table 4 (Cont'd)
Uranium Mine Underground Maintenance

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	19	0.00	0.00	0
>0-1	126	48.05	0.38	71
>1-2	33	46.00	1.39	69
>2-5	23	73.00	3.17	91
>5-20	3	16.85	5.62	84
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	204	183.90	0.90	79
				Five year period 1995-1999
0	35	0.00	0.00	0
>0-5	253	363.55	1.44	68
>5-25	79	773.80	9.79	56
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	367	1137.35	3.10	59

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.2093
μ: -2.0459
σ^2: 2.1668
Sample size: 185
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

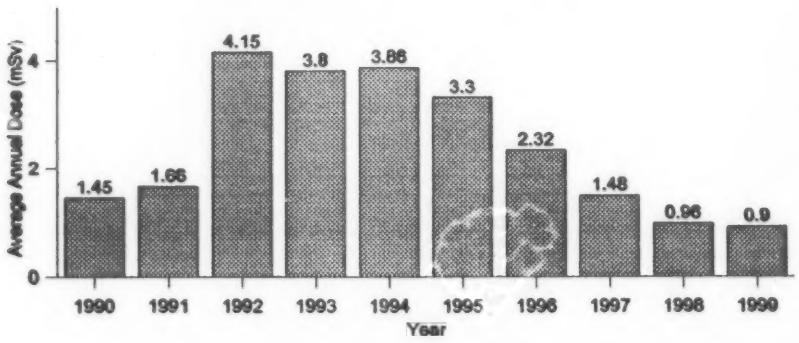


Table 4 (Cont'd)
Uranium Mine Underground Miner

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	14	0.00	0.00	0
>0-1	94	40.20	0.43	87
>1-2	72	108.35	1.50	77
>2-5	105	366.00	3.49	60
>5-20	56	371.30	6.63	59
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	341	885.85	2.60	63
				Five year period 1995-1999
0	32	0.00	0.00	0
>0-5	454	747.30	1.65	63
>5-25	382	5112.80	13.38	51
>25-100	103	3840.05	37.28	38
>100	0	0.00	0.00	0
Total	971	9700.15	9.99	47

Hybrid lognormal parameters for positive doses in 1999:
ρ: 0.4957
μ: +1.1000
σ^2: 5.2300
Sample size: 327
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

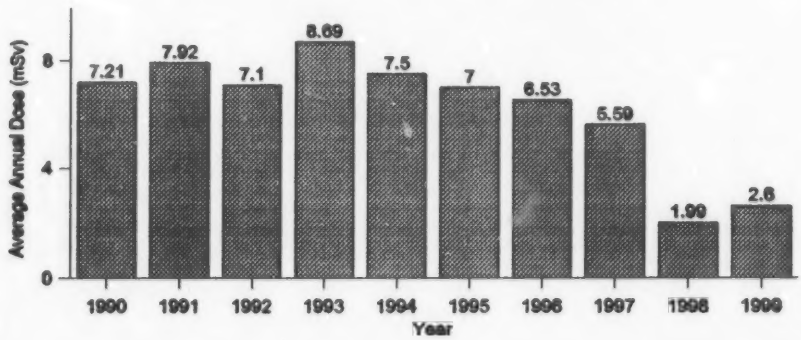


Table 4 (Cont'd)
Uranium Mine Underground Personnel

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	39	0.00	0.00	0
>0-1	61	27.70	0.45	70
>1-2	29	44.95	1.55	79
>2-5	24	73.65	3.07	74
>5-20	2	10.90	5.45	19
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	155	157.20	1.01	71
				Five year period 1995-1999
0	362	0.00	0.00	0
>0-5	373	450.80	1.21	55
>5-25	62	589.00	9.50	50
>25-100	3	102.95	34.32	61
>100	0	0.00	0.00	0
Total	800	1142.75	1.43	53

Lognormal parameters for positive doses in 1999:
ρ: 0.4784
μ: -0.2927
σ^2: 2.7875
Sample size: 116
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999

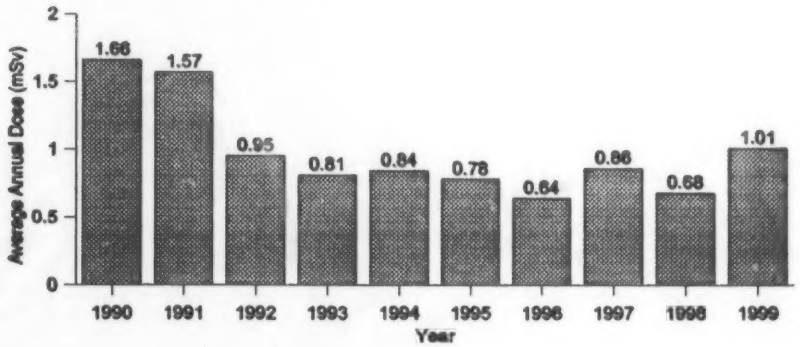
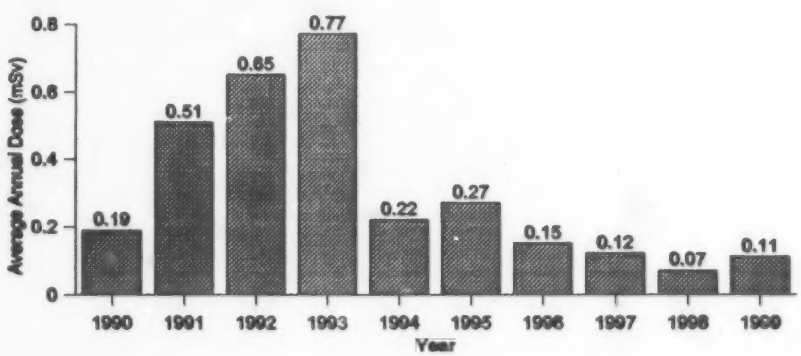


Table 4 (Cont'd)
Uranium Mine Visitor

Dose Interval (mSv)	Number of Workers	Collective Dose	Average Dose	% Radon Progeny
				Year 1999
0	88	0.00	0.00	0
>0-1	151	26.00	0.17	89
>1-2	0	0.00	0.00	0
>2-5	0	0.00	0.00	0
>5-20	0	0.00	0.00	0
>20-50	0	0.00	0.00	0
>50	0	0.00	0.00	0
Total	239	26.00	0.11	89
				Five year period 1995-1999
0	372	0.00	0.00	0
>0-5	491	180.95	0.37	53
>5-25	2	11.05	5.53	28
>25-100	0	0.00	0.00	0
>100	0	0.00	0.00	0
Total	865	192.00	0.22	51

Lognormal parameters for positive doses in 1999:
μ: -2.2032
σ^2: 0.7807
Sample size: 151
(See Appendix for explanation)

Histogram of average annual doses over ten year period 1990-1999



Appendix
The lognormal and hybrid lognormal distributions

The appendix explains how the data can be fitted to a statistical distribution, so that: (1) the sample of doses can be described by 3 or 4 quantities (the parameters of the distribution and sample size); and, (2) from these quantities, any dose statistic can be estimated, including any statistic not listed in this report, such as the 9-th decile.

Statistical distributions, such as the lognormal or hybrid lognormal distribution, are defined by a probability density function, containing a variable x, which in our case represents the occupational dose. This function is interpreted as follows:

The probability that a dose value lies between a and b equals

$$\int_a^b f(x)dx \quad ,$$

where f represents the probability density function.

Besides the variable (occupational dose) the probability density function contains a number of parameters, which determine the shape of the function. Only when the parameters have been specified is the statistical model for the occupational dose defined. Parameters are adjusted to fit the data.

The lognormal probability density function f is given by:

$$f(x: \mu,\sigma^2)=(1/x)(2\pi\sigma^2)^{-\frac{1}{2}} \exp(-\ln(x)-\mu)^2/2\sigma^2)$$

The hybrid lognormal probability density function f is given by:

$$f(x: \gamma,\mu,\sigma^2)= (\gamma+1/x)(2\pi\sigma^2)^{-\frac{1}{2}}\exp(-\ln(\gamma x)+\gamma x-\mu)^2/2\sigma^2)$$

In these functions, the quantities μ and σ^2 are parameters of the distribution. The hybrid lognormal distribution contains an extra parameter γ. This distribution was introduced by Kumazawa[9] *et al*, for the purpose of describing a workforce that makes a sustained effort to stay below a regulatory limit. This distribution often gives a better fit than the lognormal distribution for certain high dose occupations, such as nuclear medicine workers. It is similar to a lognormal distribution for low doses and to a normal distribution for high doses.

If the parameters for the probability density function f are known, one can estimate any dose statistic. For example, the mean dose is estimated as

$$\int_0^\infty xf(x)dx$$

(since the dose values x are between 0 and infinity).

The variance of the dose is estimated as:

$$\int_0^\infty (x-\text{mean})^2 f(x)dx$$

and the standard deviation as the square root thereof.

The probability that a dose exceeds, for example, 50 mSv, is estimated as:

$$\int_{50}^\infty f(x)dx \quad .$$

The 95-th percentile is estimated as that dose value v for which:

$$\int_v^\infty f(x)dx = 95/100 \; .$$

The fraction of the collective dose due to doses exceeding 15 mSv is estimated as:

$$\frac{\int_{15}^\infty xf(x)dx}{\int_0^\infty xf(x)dx}$$

The parameters are determined from the actual dose data. They are chosen to give the best "fit" with the sample of observed data, for which purpose there exists a variety of methods. The parameters in Table 4 have been estimated with the Maximum Likelihood method. With this method, dose statistics can be estimated with the formulas given above, with the tabulated parameter values substituted for (□,) μ, and □².

Software is available from the authors for the purpose of estimating occupational dose statistics and their confidence intervals. Since the lognormal and hybrid lognormal distribution do not apply to zero doses, as evident from the formulas of their probability density functions, the software will determine parameters based on positive doses only. Estimates for the total of all doses can be derived if the numbers of zero and positive doses in the sample are taken into account. For example, consider a sample in which half the doses are zero. If the parametric estimate is 2 mSv for the mean of the positive doses, then the estimate of the mean of all doses is 1 mSv. Or, if a parametric estimate for the 95-th percentile of all doses is needed, it is calculated as the estimate of the 90-th percentile for the positive doses.